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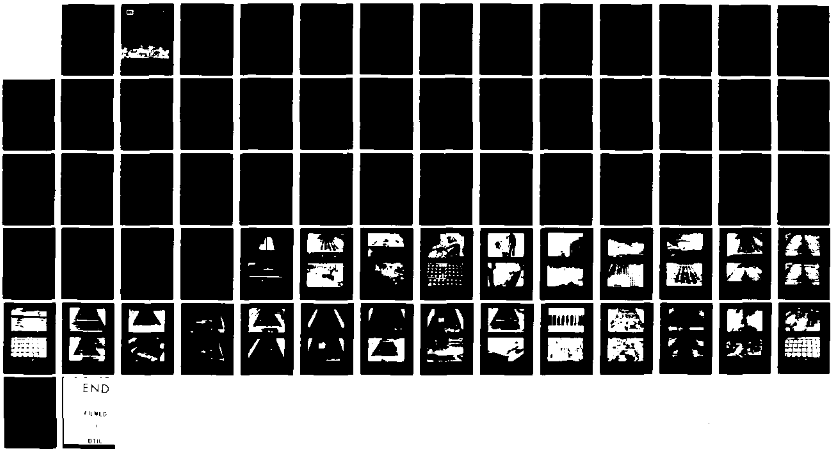

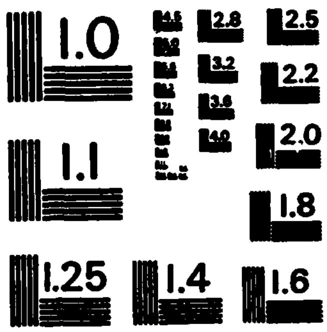

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EVALUATION OF SOD SAVER BLOCKS AND M. C. GILL PANELS FOR TACTICAL BRIDGE ACCESS/EGRESS APPLICATIONS

by

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October 1982

Final Report

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this investigation was to evaluate the performance of Sod Saver Blocks and M. C. Gill panels when subjected to 2000 to 3000 passes of vehicle traffic with loadings up to and including 10 percent maximum military load class (MLC) 60 (later changed to MLC70) as stated in the Letter of Agreement (LOA) for access/egress surfacing.

The Sod Saver Blocks and M. C. Gill panels were placed on a prepared

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20. ABSTRACT (Continued)

clay (CH) subgrade having a CBR of approximately 1.4. Two separate tests were conducted on the Sod Saver Blocks. For test 1, the blocks were held together with 1/2-in.-wide nylon plastic-coated straps. For test 2, the blocks were held together with steel rings made from 3/16-in.- and 1/4-in.-diam rods for items 1 and 2, respectively.

Accelerated traffic was applied using an M54, 5-ton military truck loaded with 20,000 lb for a gross load of 40,000 lb, and with tires inflated to 70 psi. An M48 tank was also used with a total gross load of 140,000 lb. The tank traffic was applied intermittently with the truck traffic. All panels in both tests failed to satisfy the LOA requirements for an access/egress surfacing system with the M. C. Gill panels sustaining the highest number of vehicle passes with 67 percent of MLC 60 loading as required by the LOA.

Conclusions based on the results of the tests conducted in this study are:

a. No further testing should be conducted on the Sod Saver Blocks or the M. C. Gill panels in an effort to satisfy the LOA requirements for an access/egress surfacing system.

b. Research should continue in order to develop a surfacing that would provide the necessary structural strength for the tactical vehicles used in bridge access/egress operations.

PREFACE

This study was conducted under DA Project No. 4A762719AT40, Task BO, Work Unit 028, titled "Access/Egress System for Improved Mobility in Soft Soils," sponsored by the Office, Chief of Engineers, U. S. Army.

The traffic tests pertinent to this investigation were performed at the U. S. Army Engineer Waterways Experiment Station (WES) during May and July 1981 and the report was written under the general supervision of Dr. D. C. Banks, Acting Chief, Geotechnical Laboratory (GL), and Dr. W. F. Marcuson III, Chief, GL. Personnel of the Pavement Systems Division, GL, actively engaged in the planning, testing, analyzing, and reporting phases of the investigation were Messrs. S. G. Tucker, H. L. Green, D. W. White, Jr., G. L. Carr, and D. A. Ellison. Construction and trafficking of the test section was under the supervision of Messrs. A. H. Joseph (retired), J. W. Hall, and R. W. Grau. This report was prepared by Mr. Dave A. Ellison.

The Commander and Director of WES during the conduct of this study and preparation of this report was COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	2.54	centimetres
pounds (force) per cubic foot	157.0874585	newtons per cubic metre
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6894.757	pascals
pounds (mass)	0.4535924	kilograms
tons (2000 pounds, mass)	907.1847	kilograms

EVALUATION OF SOD SAVER BLOCKS AND M. C. GILL PANELS FOR TACTICAL BRIDGE ACCESS/EGRESS APPLICATIONS

PART I: INTRODUCTION

Background

1. Military operations require rapidly emplaced gap crossings to enable troops to effectively counter enemy threats. Emplaced gap crossings must be capable of allowing mission-essential traffic to cross before enemy threats are effectively applied and of maintaining subsequent traffic flow. Poor soil conditions and steep slopes along riverbanks and streambanks must be overcome to allow movement by tactical assault vehicles at the most tactically advantageous locations.

2. In concept, the desired egress capability will be used primarily in the assault phase of tactical riverine crossing operations. Ideally, the capability should be obtained through the use of inventory depot items by engineers in the main battle area to aid the riverine crossing of swimming and fording vehicles and to gain access to bridges or raft-loading points for assault and follow-up forces.

3. From July to September 1978, military inventory items--T-17 membrane, and M19 and M8A1 aircraft landing mats--were tested in the access/egress program at the U. S. Army Engineer Waterways Experiment Station (WES). These tests revealed that all of these items failed to meet the goals in a tactical access/egress system stated in the Letter of Agreement (LOA) between Headquarters, U. S. Army Materiel Development and Readiness Command (DARCOM) and Headquarters, U. S. Army Training and Doctrine Command (TRADOC). WES Miscellaneous Paper GL-80-17* gives the results of these tests.

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* G. L. Carr and W. E. Willoughby. 1980. "Traffic Slope Tests of Military Inventory Items and Their Effectiveness in Riverine Egress Tests," Miscellaneous Paper GL-80-17, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Purpose and Scope

Purpose

4. The purpose of this investigation was to evaluate the performance of Sod Saver Blocks and M. C. Gill panels when subjected to 2000 to 3000 passes of vehicle traffic with loadings up to and including 10 percent maximum military load class (MLC) 60 (later changed to MLC 70) as stated in the Letter of Agreement (LOA) for access/egress surfacing. Since the previous tests conducted in 1978 revealed that all military inventory items failed to meet the goals in a tactical access/egress system stated in the LOA, this investigation represents a continuous effort to explore new materials, attachments, and new techniques for rapid deployment of surfacing materials in combat areas. Mainly, the desired materials must be capable of carrying the equipment loads in the MLC 60 and MLC 70 classes as prescribed in the LOA* for access/egress surfacing. Some of the requirements in the LOA are given in part as follows:

> a. Effectiveness. The proposed system is expected to provide significant reductions in the cost of time/resources in preparing access/egress routes, since it will be emplaced quickly by fewer people without the use of heavy earth-moving equipment.
>
> b. Bridge traffic access/egress role. The system must provide roadways capable of withstanding 2000 to 3000 vehicle passes (10 percent rated at MLC 70). The system will enable one platoon (30 men) of the Engineer Combat Company (Corps), using current organic equipment to install single, 4-metre lanes at the rate of 250 to 300 metres in 45 min.

Scope

5. Two different materials were procured in small experimental quantities for evaluation in this study. One of these materials, the Sod Saver Block, was an off-the-shelf item manufactured from recycled plastic wastes. Two separate tests were conducted on this material, in

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* Welker, R. W. 1979. "Letter of Agreement (LOA) for a Tactical Bridge Access/Egress, USATRADOC ACN 38653," Headquarters, U. S. Army Training and Doctrine Command, Fort Monroe, Va.

an attempt to find a suitable connector for connecting the blocks. The other item was designed by the fabricator and was supplied in a standard commercial size. These materials were examined physically for comparisons with respect to weight, cost, load-carrying ability for a rolling wheel load on a low-strength subgrade, and the feasibility of the materials satisfying other structural requirements as prescribed in the LOA for access/egress surfacing.

Definition of Pertinent Terms

6. For information and clarity, certain items used in this report are defined as follows:

- a. Test materials: Sod Saver Blocks and M. C. Gill panels.
- b. Test section: A prepared area on which the test materials are placed for tests.
- c. Subgrade: The portion of the test section constructed with soil upon which the test materials are placed.
- d. California Bearing Ratio (CBR): A measure of the bearing capacity of the soil based upon its shearing resistance. CBR is calculated by dividing the unit load required to force a 1.95-in.*-diam piston into the soil to a depth of 0.1 in. by the unit load required to force the same piston the same depth into a standard sample of crushed stone, and then multiplying by 100.
- e. Test vehicle: Vehicle used to apply traffic on test materials when placed on the test section.
- f. Wheel path: Area of test section that right or left wheels of the test vehicle traversed as the vehicle moved over the test section.
- g. Load wheels: Wheels of the test vehicle that support the major portion of the payload.
- h. Pass: One trip of the test vehicle across the test section.
- i. Run: A strip of access/egress surfacing equal to one panel width that extends transversely (perpendicular to the traffic lane) across the entire test section.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

PART II: TEST MATERIALS

Sod Saver Blocks

7. The Sod Saver Blocks (Photo 1) are primarily used as landscaping blocks. They may be used wherever mud is a problem or wherever a grass turf needs protection, such as for overflow parking, recreational vehicle parking, small aircraft parking, and playgrounds and parks. Nominal dimensions of the Sod Saver Blocks are 3 ft long by 1 ft wide and 2-3/4 in. thick; the blocks contain 48 square cells 2-1/2 in. by 2-1/2 in. by 2-1/4 in. deep. On one side of each cell there is a round opening 1-3/8 in. in diam. Each block has a weight of approximately 16 lb (5.3 psf). These blocks are made from recycled plastic scrap (e.g., thermoplastic materials). Six bundles with each bundle containing 60 blocks were received for testing.

8. The Sod Saver Blocks were manufactured by Presto Products, Inc., P. O. Box 2399, Appleton, Wis. The blocks can be placed with either side as the top or bottom. The cells can be filled with soil or sand or remain open to collect natural sediment, depending on the application. The blocks should be staggered and placed perpendicular to the flow of traffic for maximum load-bearing capacity. The blocks are easy to install, can be cut to fit with an ordinary saw, and can even be nailed together with common nails.

M. C. Gill Panels

9. The M. C. Gill panels are manufactured by the M. C. Gill Corporation, 4056 Easy St., El Monte, Calif. These are sandwich panels fabricated from 2.3-psf aluminum honeycomb core with 0.050-in. fiberglass skins bonded to each side. These panels (Photo 2) are 98 in. long, by 48 in. wide, and 2-1/4 in. thick and weigh 103 lb (3.2 psf). Aluminum-edge channels, 1/8 in. thick by 1-7/8 in. wide, were bonded and bolted to all four edges. Aluminum cleat channels, 1 in. wide, 1-7/8 in. high, and 8 in. long, were bonded with epoxy glue to both top and bottom surfaces.

These channels, which act as lugs for traction, were spaced 12 in. apart and ran intermittently along the top and bottom of panel surfaces. Only 14 panels were obtained for evaluation.

PART III: TRAFFIC TEST SECTIONS, ASSEMBLY AND PLACEMENT OF TEST MATERIALS, AND TEST VEHICLES

Test I

Test section

10. The test section was located in a covered facility which helped to maintain foundation conditions during controlled traffic tests. The test section (Figure 1) was 20 ft wide and 36 ft long and was divided into two test items, each with a 13-ft-wide traffic lane. Each end of the test section had a 20-ft-long approach area for maneuvering the test vehicle. Item 1 was 20 ft long and consisted of 100 Sod Saver Blocks. Item 2 was 16 ft long and consisted of four M. C. Gill panels. A general view of the test section prior to traffic is shown in Photo 3.

11. The subgrade, which consisted of a heavy clay (CH) material, was processed to a 1 to 2 CBR for a depth of 24 in. The clay material had an average liquid limit of 58 and an average plasticity index of 33 (Figure 2). After the subgrade material had been deposited in the test section, it was spread and compacted with a small bulldozer (Photo 4). The subgrade was smoothed (Photo 5) by placing landing mat on top of it and trafficking the mat with a 48,660 lb rubber-tired roller with seven wheels inflated to 60 psi. CBR, moisture content, and density tests were conducted during construction to ensure that the desired strength was obtained. Soil data are shown in Table 1.

Assembly and placement of test materials

12. Item 1. One hundred Sod Saver Blocks were assembled in an offset staggered pattern (Photo 6) and held together with 1/2-in.-wide nylon plastic-coated straps. The plastic straps were held with metal clips fastened with a crimping tool (Photo 7). A typical joint of Sod Saver Blocks assembled with plastic straps is shown in Photo 8. The blocks were assembled on pavement and then moved to the test section and laid as individual units of two runs each. After placement, these runs were fastened together with the plastic straps. Temporary spacer blocks

were used between individual runs and at the end of the panels to allow for hinging action. These steps are shown in Photos 9 and 10, respectively.

13. Item 2. M. C. Gill panels were fastened together with steel plates, 6 in. wide, 1/8 in. thick, and 6 ft long, bolted to the edge of the top and bottom of each panel (Photo 11). Four panels were assembled by this method and placed on the subgrade to complete item 2 of the test section. These panels were placed in this manner for evaluation of the structural properties only; this is not a recommended procedure for field placement, since the panels would contain connections as part of basic design.

Test vehicles

14. A 5-ton, 6 by 6, M-54 military cargo truck with winch, loaded to 20,000 lb (gross weight 40,000 lb) was used as one of the test vehicles in the traffic tests (Photo 12). The 11 × 20 12-ply tires were inflated to 70 psi. A layout of the wheel spacing of the test vehicle is shown in Figure 3. The other test vehicle used was an M48A1 tank loaded to 106,000 lb (Photo 13. A layout of the track spacing of this test vehicle is shown on Figure 4.

Test II

Test section

15. The test section was located in the same facility as the test section in test I. The test section was 20 ft wide by 20 ft long and included two items with an approach area at each end (Figure 5). The subgrade for the test section was constructed in a manner similar to test I, using the same type material (Figure 2) and a CBR in the same range. CBR, moisture content, and density tests were conducted during construction to ensure that the desired strength was obtained. Soil data are shown in Table 1.

Assembly and placement of test materials

16. Item 1. Fifty Sod Saver Blocks were assembled using steel

rings made from 3/16-in.-diam rods. The rings were 2-1/2 in. and 3 in. in diameter and were placed between the joints of adjacent runs on alternate sides (top and bottom) to allow the blocks to be folded at each run if desired for storage, transportation, etc. The 3-in.-diam rings were used on the top side and the 2-1/2-in. diam rings were used on the bottom side of the blocks. This arrangement allows each run to fold without excess slack between blocks. The runs were assembled with 1-ft offsets for added strength (Photo 14). This item also contained runners 4 ft wide by 10-1/2 ft long made from the Sod Saver Blocks and placed flush with the top of the subgrade.

17. Item 2. Fifty Sod Saver Blocks were assembled in the same manner as item 1, except the steel rings were made from 1/4-in.-diam rods, and no runners were installed.

Test vehicles

18. The same M-54 military cargo truck that was used in test I was also used in test II. The same type of tank was also used; however, the total weight of the tank was increased from 106,000 to 140,000 lb (Photo 15) to agree with the revised LOA requirements.

PART IV: TRAFFIC TEST RESULTS

Test I

19. During May 1981, traffic tests were conducted on Sod Saver Blocks and M. C. Gill panels. These materials were subjected to traffic applied with the M54 cargo truck and M48A1 tank shown in Photos 12 and 13, respectively. Traffic was applied in a channelized pattern similar to actual road conditions.

Item 1

20. A general view of item 1 surfaced with Sod Saver Blocks prior to traffic is shown in Photo 16. The average subgrade strength of the top 12 in. of soil was 1.0 CBR (Table 1). After two passes with an empty M54 5-ton truck (20,000 lb), the Sod Saver Blocks were embedded approximately 1 in. into the subgrade along the wheel paths. The 5-ton truck was loaded to 30,000 lb gross weight and traffic continued for a total of ten passes. During this period, the Sod Saver Blocks continued to be embedded in the subgrade, the subgrade extruded up between joints of the Sod Saver Blocks, and the item became deformed in the wheel paths throughout. One plastic strap was broken after 8 passes. Photo 17 shows a general view of item 1 after 10 passes. The 5-ton truck was then loaded to 40,000 lb gross weight and traffic continued. A general view of item 1 after 25 passes is shown in Photo 18. Traffic was stopped after 39 passes (Photo 19) as the section was considered failed due to deep ruts (11-3/4 in.) in the wheel paths and numerous broken straps. The undercarriage of the truck was scraping the surface of the item and had pulled out several Sod Saver Blocks at the center of the traffic lane. The deflection in the west and east wheel paths is shown in Photos 20 and 21, respectively. This deformation (8-1/2 in. in the west wheel path and 11-1/2 in. in the east wheel path) was caused when the individual Sod Saver Blocks in the wheel paths became separated and were forced into and beneath the subgrade. A typical break on the bottom side of a Sod Saver Block which was located in the wheel path is shown in Photo 22.

Item 2

21. A general view of item 2 surfaced with M. C. Gill panels prior to traffic is shown in Photo 23. The average subgrade strength of the top 12 in. was the same as for item 1 (Table 1). The first 39 passes of traffic were common for item 1 and item 2. After two passes with an empty M54, 5-ton truck (20,000 lb) the panels were slightly embedded into the subgrade. The 5-ton truck loaded to 30,000 lb gross weight was used to apply the next eight passes. On the fifth pass (total count) of the 30,000-lb truck, one cleat on panel 4 was broken. After 10 passes were completed, the 5-ton truck was loaded to 40,000-lb gross weight, and traffic continued. After 30 passes of the 40,000-lb truck, the M. C. Gill panels showed no deficiencies except that a total of three cleats had become separated from the panels. After a total of 200 passes of truck traffic were completed, a total of six cleats were broken. All cleats were still in place on panels 1, 2, and 3. A general view of item 2 after 200 passes is shown in Photo 24. Traffic was continued with the 5-ton truck loaded with 40,000 lb until 1,200 passes were completed. A summary of panel failures between 200 and 1,200 passes is as follows:

- a. 700 passes. Cleat 7 on panel 2 failed. Panel 4 had a 6-in.-wide by 14-in.-long core failure plus several other surface cracks.
- b. 900 passes. Cleat 8 on panel 2 failed.
- c. 1,100 passes. Cleat 9 on panel 4 failed (core adhesive to skin failure).
- d. 1,148 passes. Cleat 10 on panel 3 was punched into the surface skin as failure occurred, causing a 14-in. to 16-in. tear in the top skin. A general view of item 2 after 1,148 passes is shown in Photo 25. A close-up of a failure in panel 3 after 1,148 passes is shown in Photo 26.
- e. 1,200 passes. Cleat 11 on panel 2 failed.

22. After the 1,200 passes of traffic with the 5-ton truck (40,000 lb gross weight) were completed, traffic was continued with the M48A1 tank loaded to 106,000 lb gross weight. Two hundred passes were applied with the M48A1 tank. The results of these passes are described as follows:

a. 1 pass. Three cleats failed on panel 4, four cleats failed on panel 2, and two cleats failed on panel 1. Photo 27 shows a cleat embedded in the core of panel 4 after 1 pass with the tank. Photo 28 shows the damage after the cleat was removed from panel 4.

b. 30 passes. The breaks in panel 3 had increased significantly, spreading in all directions.

c. 31 passes. Five additional cleats failed.

d. 32 passes. Six additional cleats failed.

e. 33 passes. Two additional cleats failed.

f. 36 passes. A surface break appeared on panel 1 approximately 40 in. long running parallel with the direction of traffic.

g. 50 passes. Traffic was continued with the tank until 50 passes were completed with no additional breaks or failures noted. A general view of item 2 after 1200 passes of truck traffic and 50 passes of tank traffic is shown in Photo 29. A 40-in. surface break in panel 1 is shown in Photo 30. A close-up of failures in panel 3 (after 50 passes of tank traffic and 1200 passes of 5-ton truck traffic) is shown in Photo 31. Only one cleat remained in place (panel 3, Photo 31) in the wheel path and there were numerous breaks in this area of the panel as described earlier.

h. 120 passes. The last remaining cleat on panel 3 failed and caused a section of the top skin approximately 8 in. by 10 in. to be torn from the surface (Photo 32).

i. 168 passes. The top skin break in panel 1 extended completely across the panel (Photo 33).

j. 194 passes. The metal edge channel on panel 1 was completely broken, and the top skin in the broken area mentioned after 168 passes was disbonded completely across the panel.

k. 200 passes. The tank traffic was discontinued after 200 passes to allow more truck traffic to continue. Photos and cross-sectional and profile data were taken. A general view of test item 2 after 200 passes with the M48A1 tank and 1200 passes with the 5-ton truck is shown in Photo 34.

23. Traffic was continued with the 5-ton truck loaded to 40,000 lb gross weight for an additional 520 passes. The test item was considered failed at this point with a total of 1,920 passes (1,720 with the 5-ton truck and 200 with the M48A1 tank). Failure of test item 2

was due to failure of panel 3, which was completely crushed in the center area (Photo 35). The skins on panels 1 and 2 were disbonded, which caused permanent deformation in these panels. Photo 36 shows the M48A1 tank (106,000 lb) on the M. C. Gill panels at failure; failure here is considered only for truck traffic. Note how the tank bridges over the failed panel. Photo 37 shows a general view of the test item. Photo 38 shows a close-up of the rear wheel of the M54 truck on failed panel 3.

24. Cross-section and profile measurements for test I, item 2 are shown in Figures 6-13. Note that cross-sectional data show the maximum difference in elevation between 39 passes and 0 passes is approximately 4.0 in. in the east wheel path at sta 0+7 ft. Maximum difference between 39 passes and 0 passes is approximately 3.6 in. in the west wheel path at sta 0+7 ft. The cross-sectional data also indicate that the soft subgrade was forced toward the center of the traffic lane and upward. This action caused a maximum differential of 8.6 in. in elevation between the west wheel rut and the center of the traffic lane at 39 passes. This condition was typical at all stations in item I. At sta 0+14 ft of the cross-sectional data, the maximum difference in elevation between 39 passes and 0 passes is 4.9 in. in the west wheel path and 4.0 in the east wheel path. The cross-sectional data in item 2 show a maximum change in elevation of 2.6 in. at the end of test (1920 passes). This deformation increased to 5.6 in. as the loaded truck stopped as shown in Photo 38. The data also show that 200 passes with the M48A1 tank only produced 0.8 in. permanent deformation. The profile data show the contrast between the small Sod Saver Blocks and the much larger M. C. Gill panels, the main contrast being that the small blocks were unable to distribute the load on the soft subgrade. Soil data (Table 1) were taken from items 1 and 2, and the average CBR's were 1.0 and 1.5, respectively. Photo 39 shows the underside of eight cleats which failed at various passes (noted on photo) during testing. These failures are described in detail as follows:

- a. Cleat 1 failed at 5 passes as a result of poor adhesive application between cleat and panel skin.
- b. Cleat 3 failed at 39 passes, due to adhesion failure (glue-metal interface).

c. Cleat 6 failed at 200 passes due to skin failure in the area of the bond.

d. Cleats 7, 8, and 10 failed at 700, 900, and 1140 passes, respectively, due to a combination of cohesion and adhesion failures.

e. Cleat 14 failed at 1 pass with the M48A1 tank. This failure was caused by metal crushing under load.

f. Cleat 26 failed at 32 passes with the M48A1 tank due to complete metal failure by breaking.

Photo 40 shows the excellent condition of the subgrade beneath panel 2 (which did not fail) after the conclusion of tests at 1920 passes (note cleats embedded in subgrade). Photo 41 shows the bottom side of all M. C. Gill panels after conclusion of traffic. The bottom skins of panels 1 and 3 were broken across the 4-ft width. The condition of these two panels caused this item to be considered failed. Photo 42 shows a close-up of the failure on the bottom side of panel 3.

Test II

25. During July 1981, traffic tests were conducted on Sod Saver Blocks fastened together with rings fabricated from two different size steel rods (3/16-in. and 1/4-in. diam). Item 1 contained the Sod Saver Blocks fastened together with the 3/16-in.-diam rings and placed over Sod Saver runners (4 ft wide by 10-1/2 ft long) in the wheel paths. Item 2 contained a single layer of the blocks fastened together with 1/4-in.-diam rods. An overall view of the test section prior to traffic is shown in Photo 43.

26. Fifty passes were made on the Sod Saver Blocks with the 5-ton M54 truck empty (20,000 lb gross weight). No broken blocks or rings were noted, although the blocks were deformed in the wheel paths (3.0 in. maximum in item 2), as shown in Photo 44. Fifty additional passes were made with the 5-ton truck loaded with 10,000 lb (30,000 lb total weight). After this traffic, the blocks in item 2 were deformed more, but no breaks were found in the blocks or the rings. Cross-sectional and profile data were taken (Figures 14-19) after a total of 100 passes were

applied with the 5-ton truck. The cross-sectional data for this item show that the average maximum differences in elevation between 0 passes and 100 passes were 3.95 and 3.75 in. in the west and east wheel paths, respectively. The permanent deformation profiles show that the maximum permanent deformation for the first 100 passes was 4.1 in. 2-1/2 ft east of the center line.

27. Twenty-five passes were then applied with the M48A1 tank loaded with a gross weight of 140,000 lb. The tank traffic embedded the blocks into the subgrade approximately 2 in. and 2-3/4 in. for items 1 and 2, respectively, but no breaks were found in the blocks or in the rings.

28. The 5-ton truck was loaded with 20,000 lb (40,000 lb total weight). Item 2 failed after 33 additional passes with this loading. The blocks in item 2 had become severely deformed, and several rings had pulled through the block ends. This condition caused the undercarriage of the truck to drag. A general view of the test section with item 2 failed after 133 passes with the 5-ton truck and 25 passes with the M48A1 tank as shown in Photo 45.

29. Traffic continued on item 1 with the 5-ton truck for a total of 300 truck and 25 tank passes. Item 1 was considered failed due to broken Sod Saver Blocks which caused deep ruts and also rings which pulled out of the block ends at the centerline, allowing the truck undercarriage to drag. The maximum rut depth was recorded at 15-5/8 in. in the west wheel path. Cross-sectional and profile data are shown in Figures 14-19. The cross-sectional data in item 1 show that the average maximum difference in elevation between 0 passes and 100 passes was 1.7 and 2.0 in. in the west and east wheel paths, respectively. The same data taken after 300 passes at the same locations showed average maximum elevation differences of 6.8 and 7.0 in. in the west and east wheel paths, respectively. The average maximum difference in elevation when measured on the block surface was 11.1 in. (measured from bottom of rut to highest point at center of traffic lane), as shown in Figures 16-17. The permanent deformation profiles show that for each additional 100 passes applied, the average maximum deformation increased 2.02 in. at

2-1/2 ft east of the center line and 2.47 in. at 3-1/2 ft east of the center line. These data also indicate how the subgrade was displaced, as discussed earlier. A general view of this failed item is shown in Photo 46. A close-up of the failed blocks is shown in Photo 47. Broken blocks and rings pulled loose from panel ends are shown in this photograph. A close-up of a typical break in a Sod Saver Block is shown in Photo 48.

PART V: SUMMARY OF TEST RESULTS AND RECOMMENDATIONS

Summary of Results

Test I

30. Item 1. Sod Saver Blocks when secured together with plastic straps and subjected to access/egress traffic supported the following vehicle traffic passes before failure:

a. Two passes of M54 cargo truck (20,000 lb gross weight).

b. Eight passes of M54 cargo truck (30,000 lb gross weight).

c. Twenty-nine passes of M54 cargo truck (40,000 lb gross weight).

The Sod Saver Blocks in this item sustained only 1.4 percent of the vehicle passes (other than MLC 60 loading) and 0 percent vehicle passes of MLC 60 loading as required by the LOA. In order for a material to be considered as a candidate for access/egress surfacing, the material(s) must sustain 2000 to 3000 passes (10 percent rated at MLC 60) vehicle traffic. (The MLC was revised from 60 to 70 between test I and test II.)

31. Item 2. The M. C. Gill panels when subjected to access/egress traffic supported the following vehicle traffic passes before failure:

a. First 10 passes same as Sod Saver Blocks above (subparagraphs 29a and 29b).

b. An additional 1,190 passes of the M54 cargo truck (40,000 lb gross weight).

c. Two hundred passes of the M48A1 tank (106,000 lb gross weight).

d. Five hundred and twenty additional passes of the M54 cargo truck (40,000 lb gross weight).

The M. C. Gill panels in this item sustained only 64 percent of vehicle passes (other than MLC 60) and 67 percent of vehicle passes of MLC 60 loading as required by the LOA.

Test II

32. Item 1. Sod Saver Blocks when secured with 3/16-in.-diam rods fabricated into rings and placed on Sod Saver Block runners (4 ft

wide and 10-1/2 ft long) in the wheel paths and subjected to access/egress traffic supported the following traffic passes before failure:

- a. First 158 passes same as Sod Saver Blocks (subparagraphs 32a, 32b, 32c, and 32d).
- b. An additional 167 passes of the M54 cargo truck (40,000 lb gross load).

33. Item 2. Sod Saver Blocks when secured with 1/4-in.-diam rods fabricated into rings and subjected to access/egress traffic supported the following traffic passes before failure:

- a. Fifty passes of the M54 cargo truck (20,000 lb gross load).
- b. Fifty passes of the M54 cargo truck (30,000 lb gross load).
- c. Twenty-five passes of the M48A1 tank (140,000 lb gross load, MLC 70).
- d. Thirty-three passes of the M54 cargo truck (40,000 lb gross load).

The Sod Saver Blocks in this item sustained only 5 percent of vehicle passes (other than MLC 70) and 8.3 percent of vehicle passes of MLC 70 loading as required by LOA.

Recommendations

34. Based on the results of the tests conducted in this study, the following recommendations are warranted:

- a. No further tests should be conducted on the Sod Saver Blocks nor on the M. C. Gill panels in an effort to satisfy the LOA requirements for an access/egress surfacing system.
- b. Research should continue in order to develop a surfacing that would provide the necessary structural strength for the tactical vehicles used in bridge access/egress operations.

Table 1

Summary of Water Content Density and CBR Data

No. of Passes	Location	Depth in.	Water Content*	Dry Density* pcf	CBR*	Rated CBR
			Test 1			
0	Item 1 (center)	0	29.8	81.9	1.2	1.3
		6	34.4	82.2	1.0	
		12	32.0	80.2	0.8	
0	Item 2 (center)	0	33.9	82.1	1.1	
		6	34.5	80.8	0.9	
		12	35.1	80.6	1.1	
1920	Item 2	0	34.3	83.1	1.9	
		6	34.7	80.4	1.4	
		12	33.2	83.7	1.3	
			Test 2			
0	Center of section	0	35.3	82.0	1.5	1.4
		6	34.8	82.8	1.6	
		12	36.2	81.3	1.6	
300	Under east runner	0	35.0	82.1	1.6	
		6	36.4	79.7	1.4	
		12	40.0	76.0	0.8	

* Each measurement is an average of three readings at each depth.

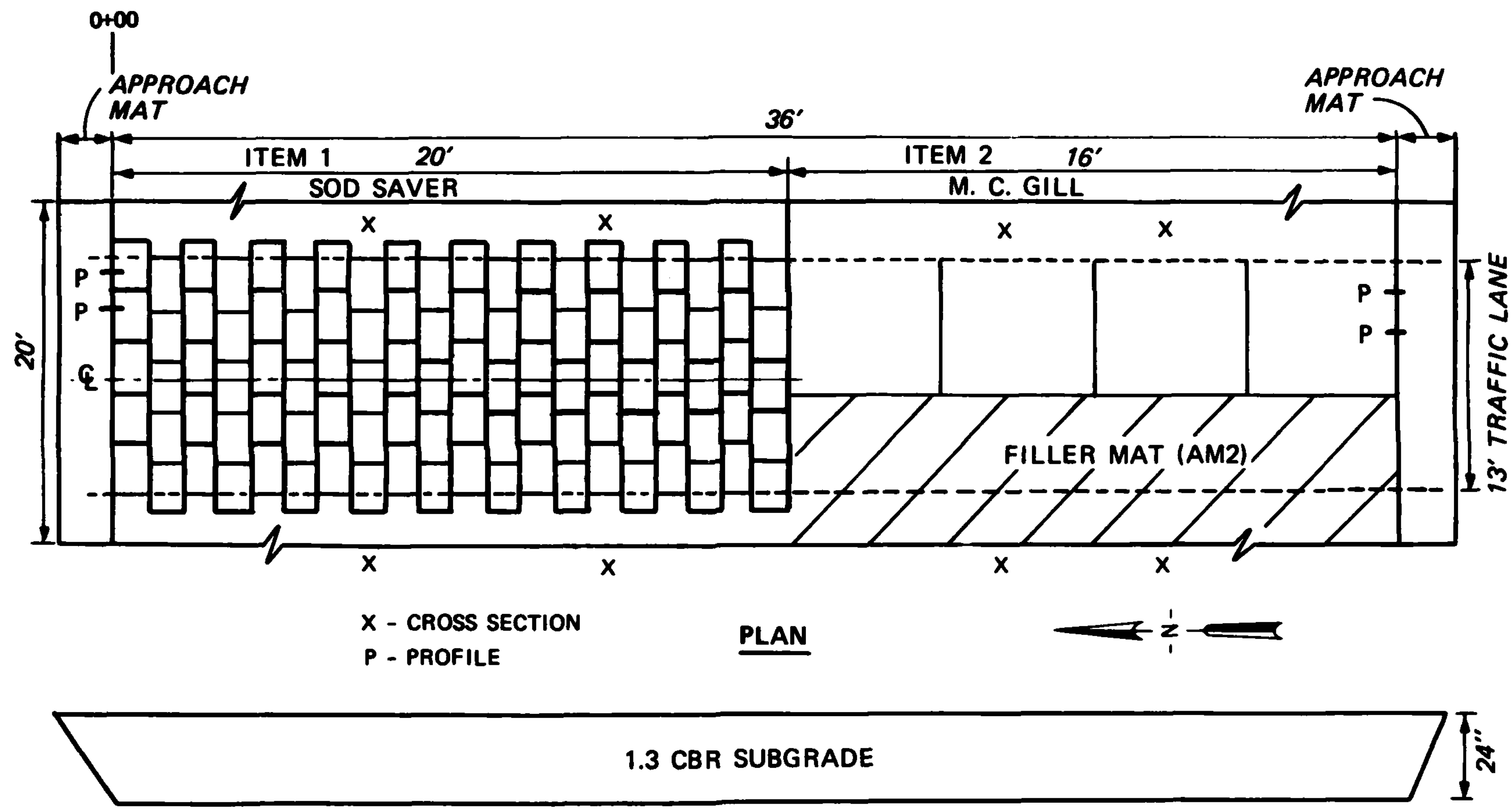
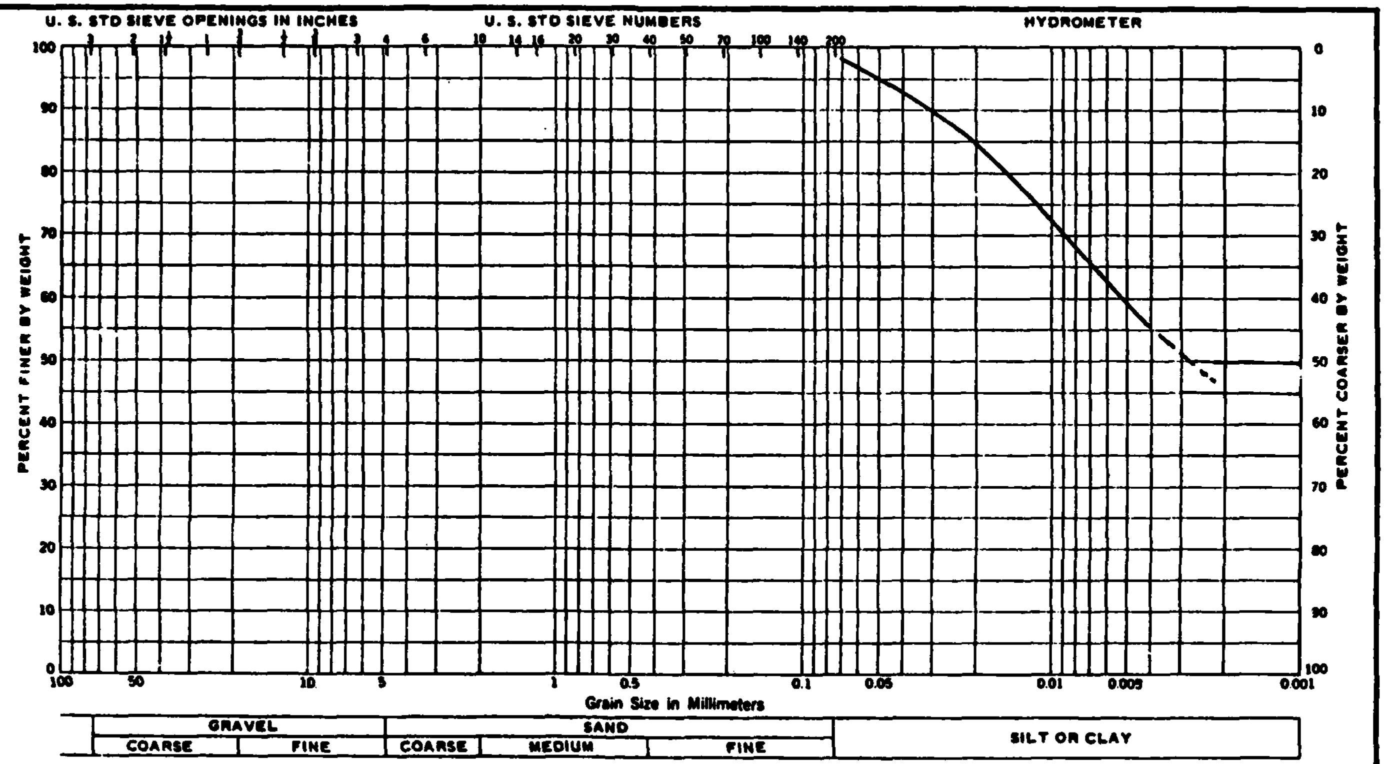


Figure 1. Test section layout, M. C. Gill panels and Sod Saver Blocks, test I



NO.	DEPTH	NATURAL MOISTURE	L.L.	P.L.	P.I.	CLASSIFICATION
			58	25	33	CLAY (CH)

CLASSIFICATION DATA

SUBGRADE SOIL

Figure 2. Classification data for subgrade soil

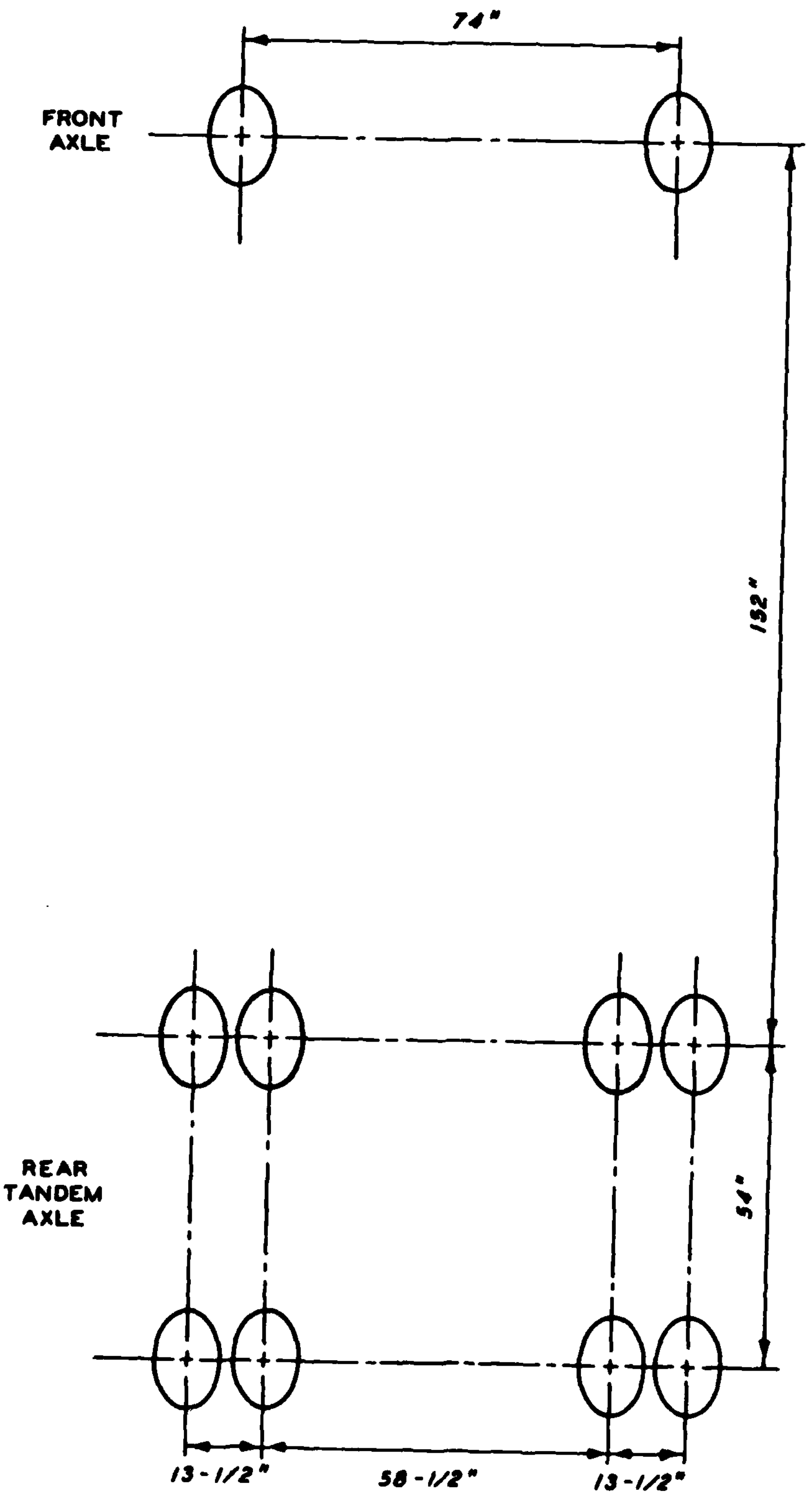
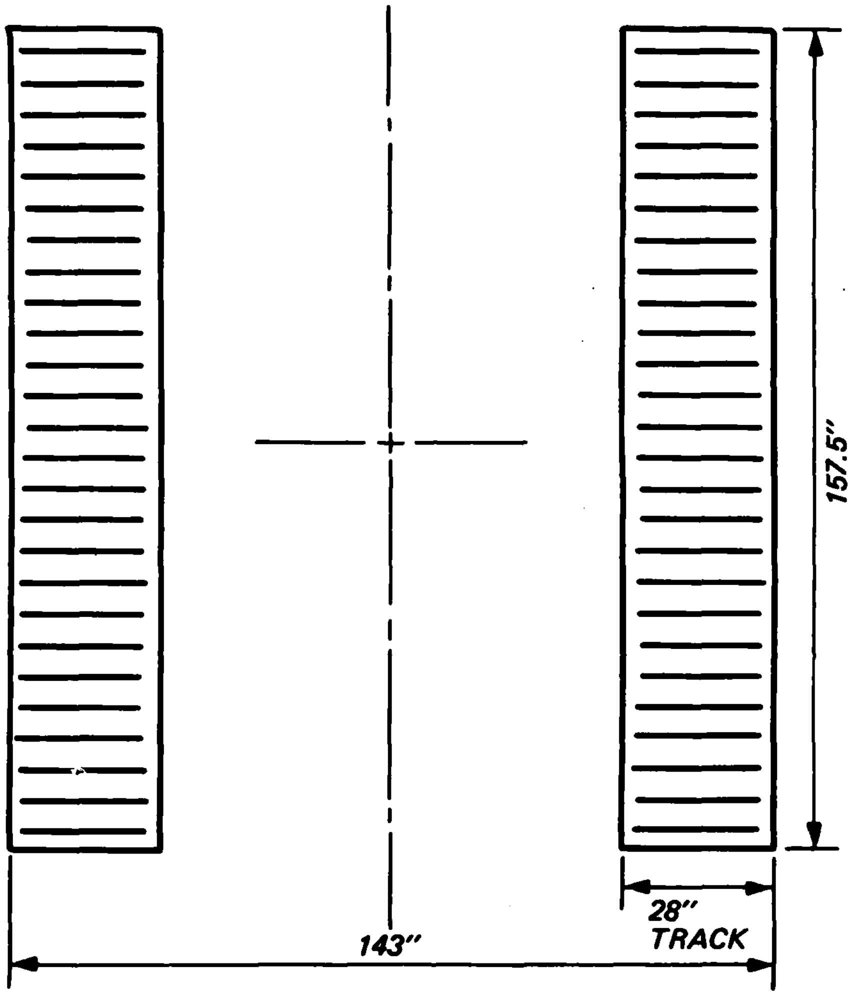


Figure 3. M54 cargo truck wheel configuration with total contact area of 589.2 sq in.



SCALE: 1" = 30"

Figure 4. M48A1 tank track configuration

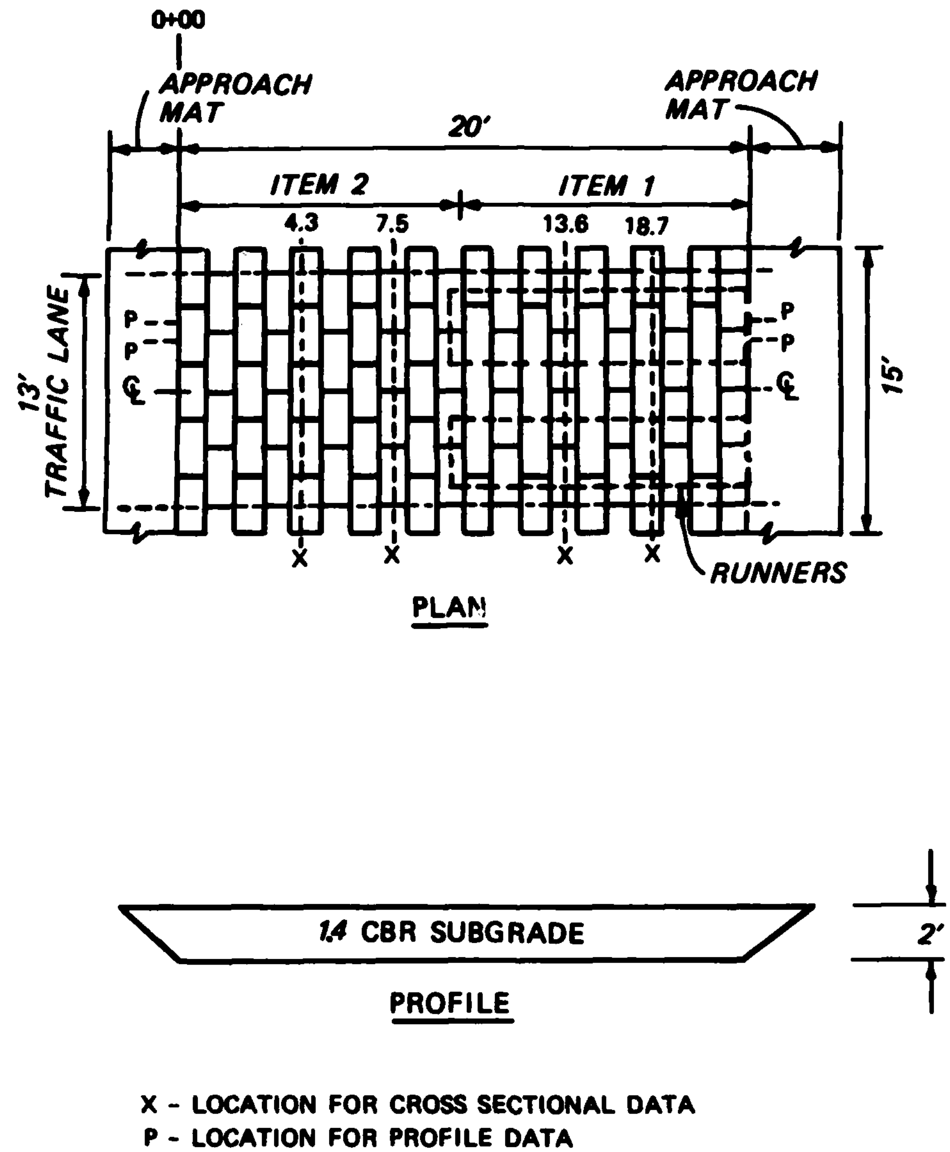


Figure 5. Test section layout for Sod Saver Blocks, test II

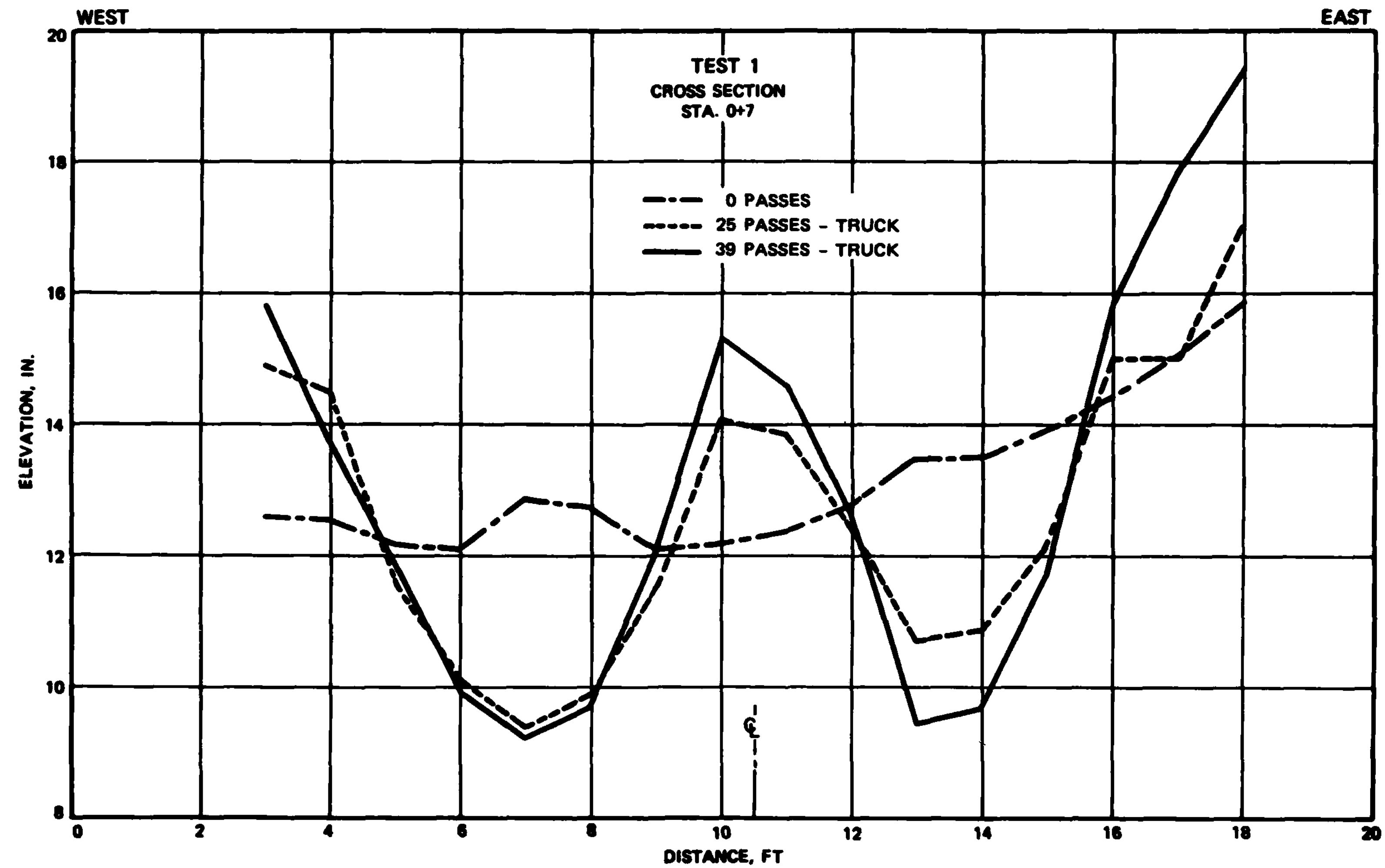


Figure 6. Cross sections, test I, item 1, sta 0+7

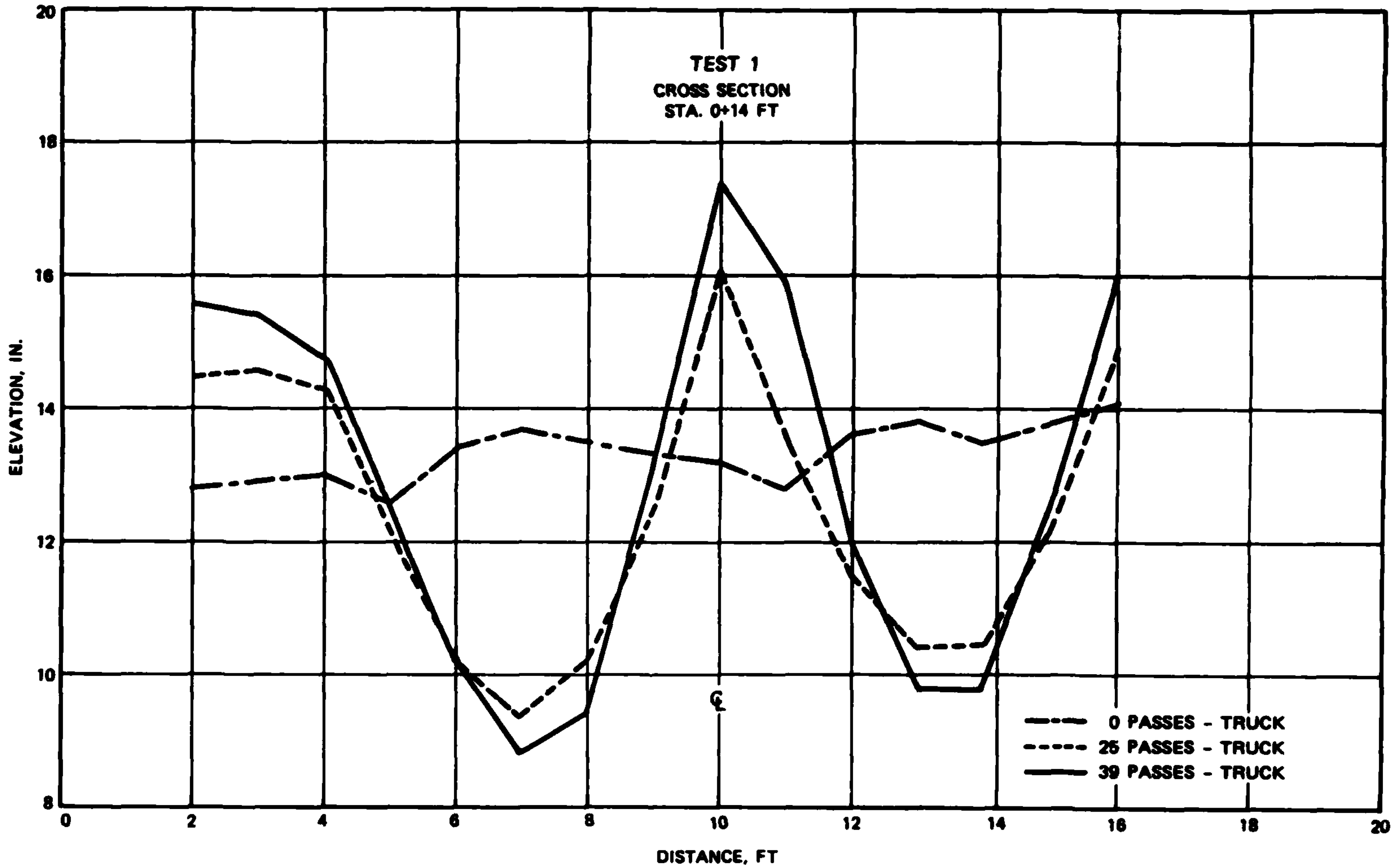


Figure 7. Cross sections, test I, item 1, sta 0+14

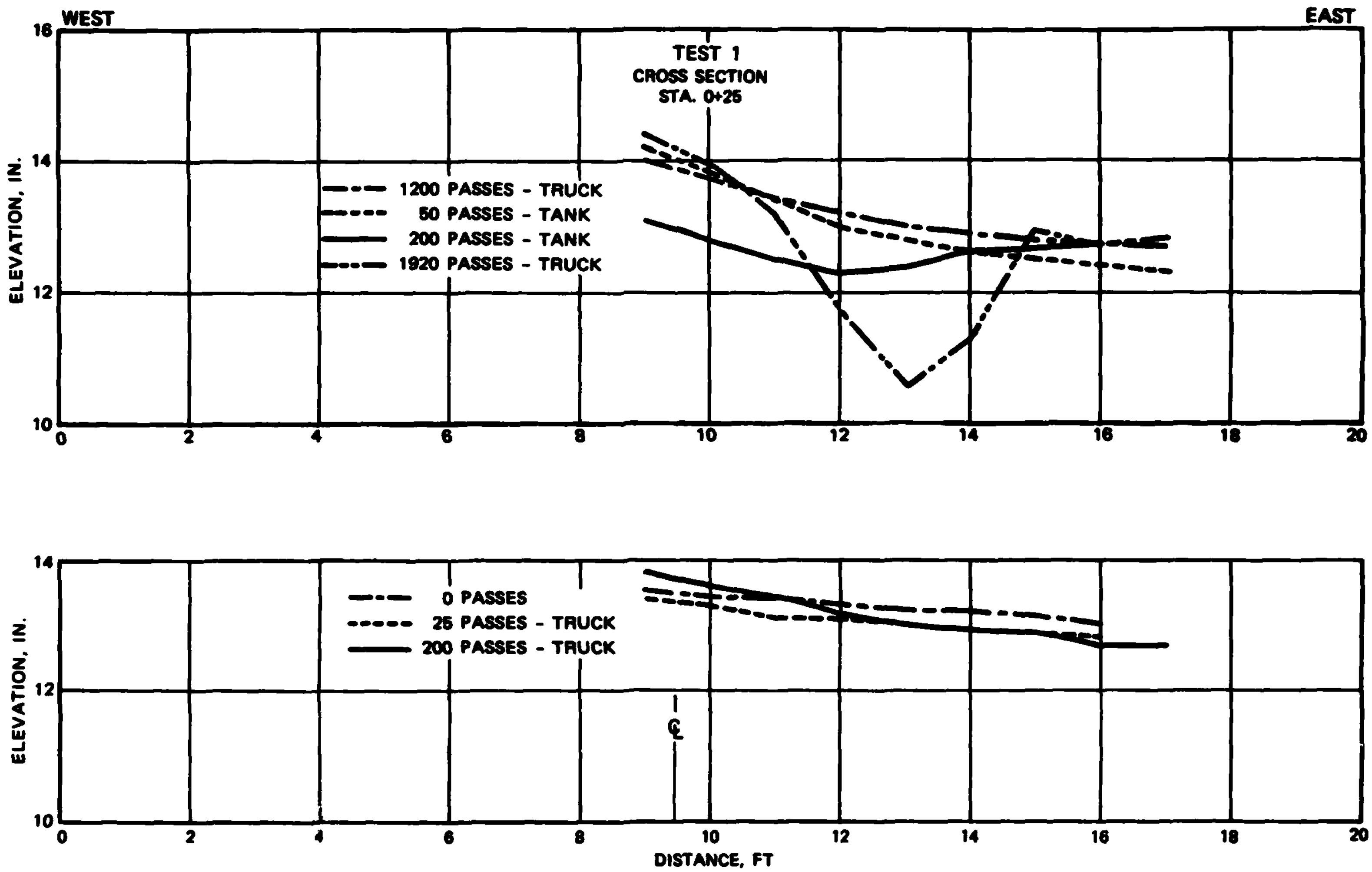


Figure 8. Cross sections, test I, item 2, sta 0+25

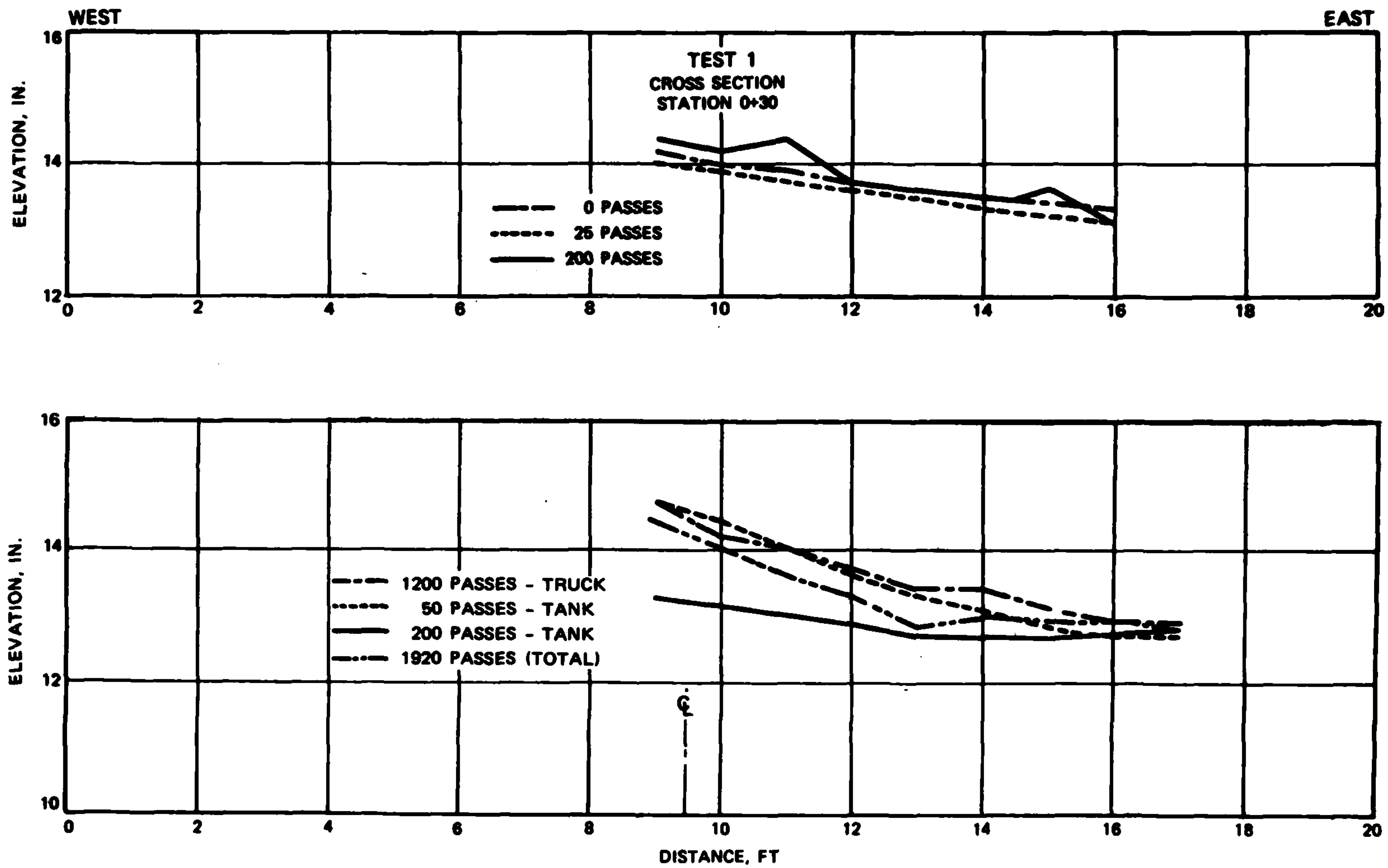


Figure 9. Cross sections, test I, item 2, sta 0+30

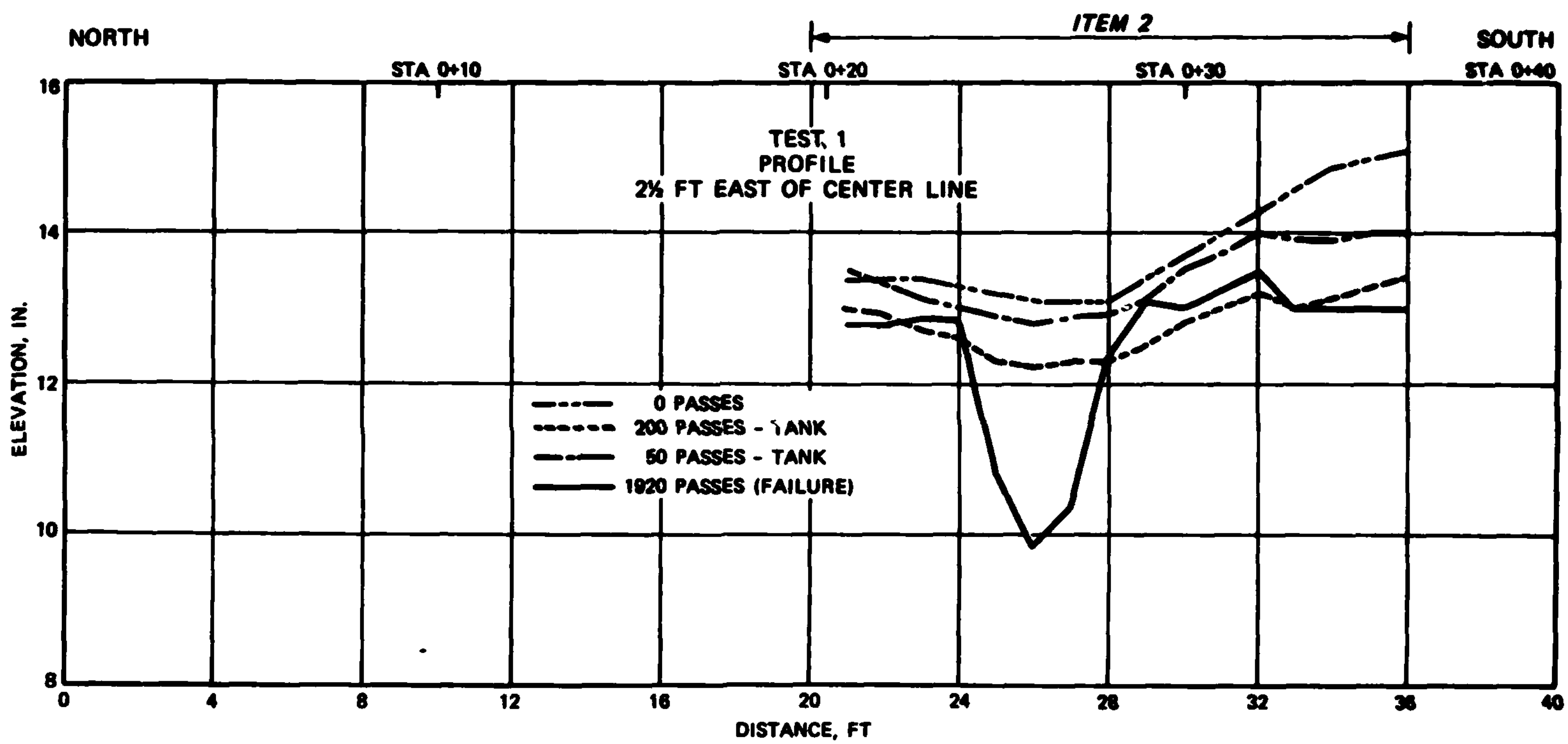


Figure 10. Permanent deformation profiles, test I, item 2

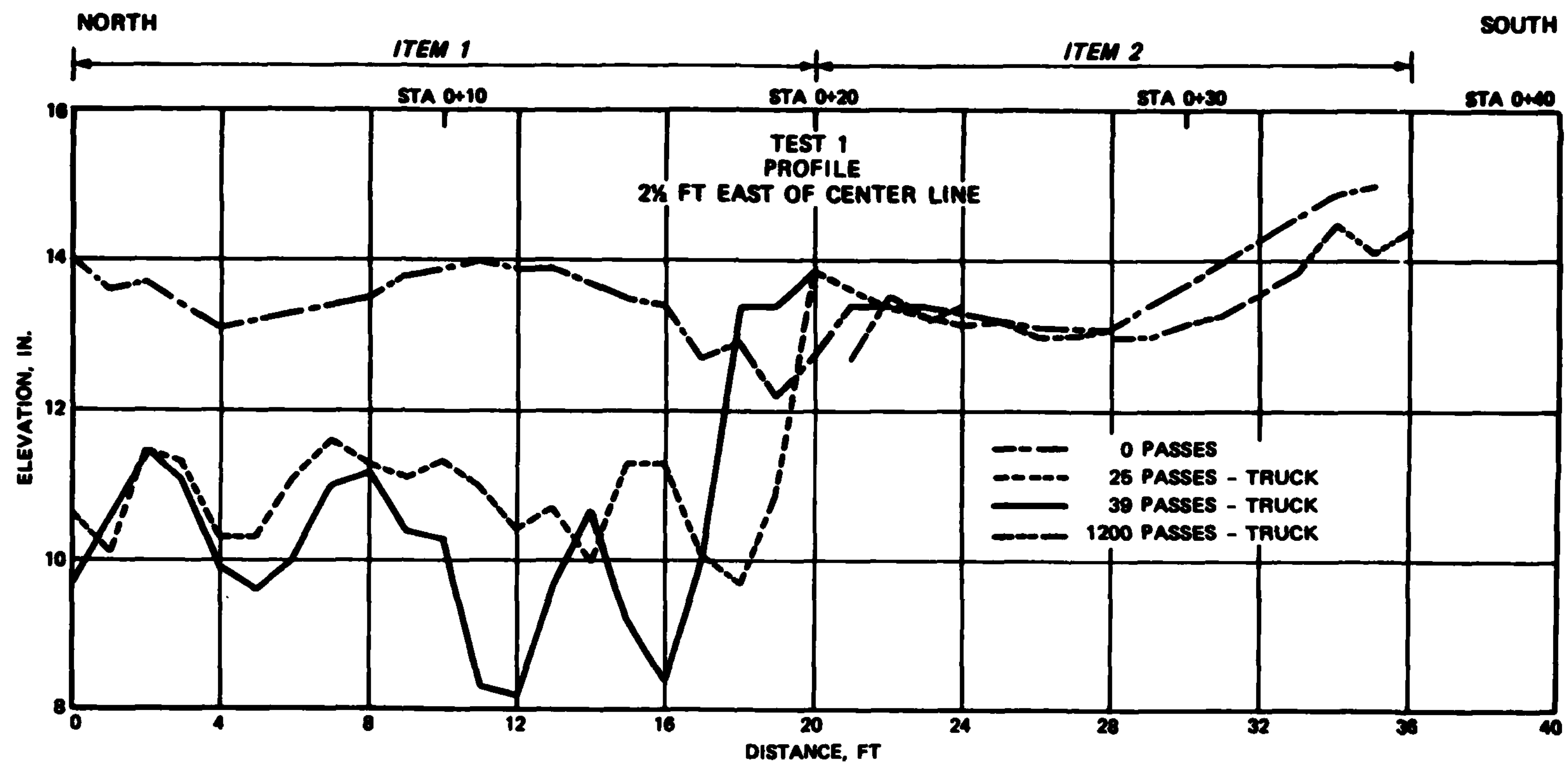


Figure 11. Permanent deformation profiles, test I, items 1 and 2, 2.5 ft east of center line

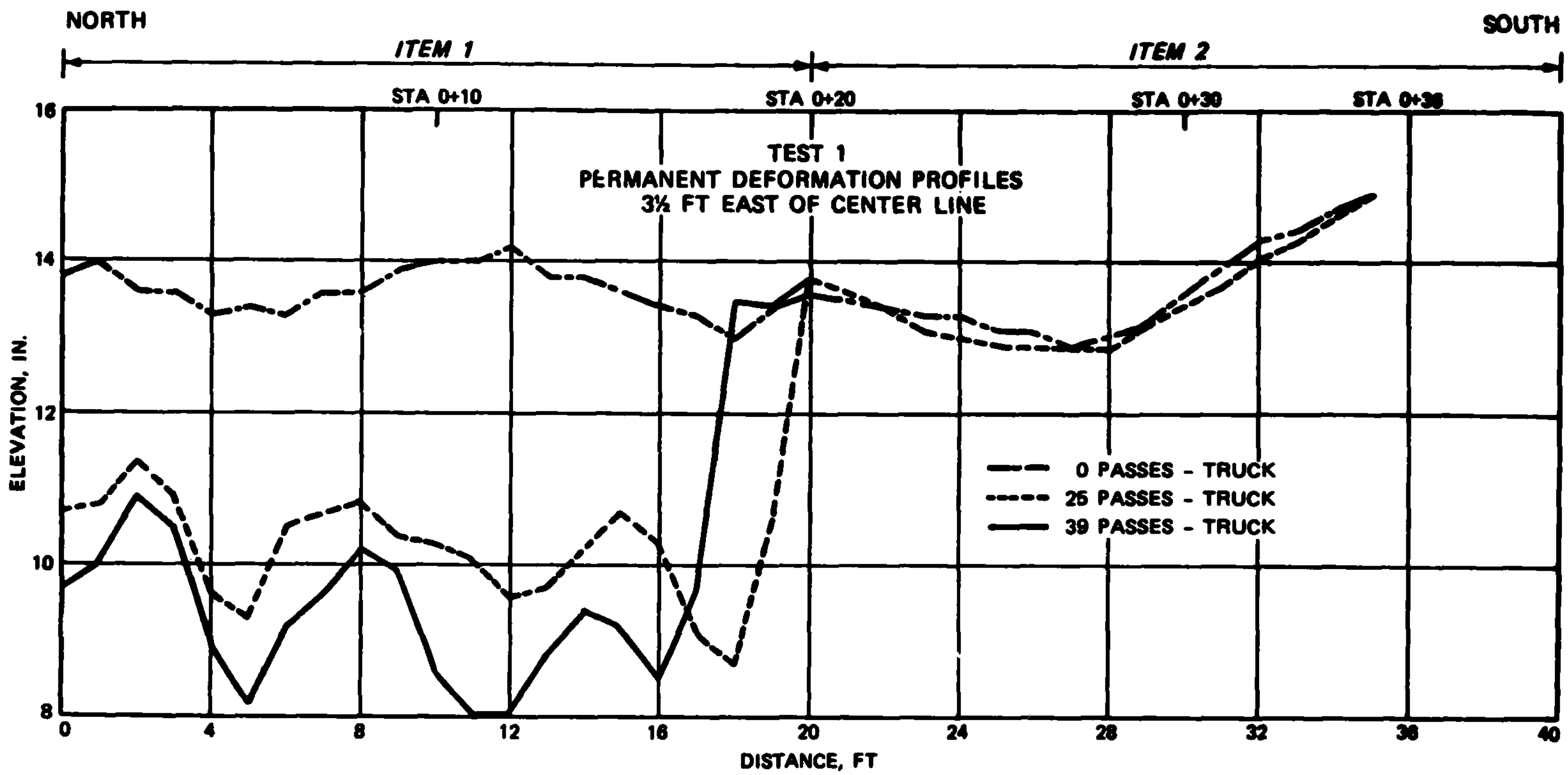


Figure 12. Permanent deformation profiles, test I, items 1 and 2, 3 ft east of center line

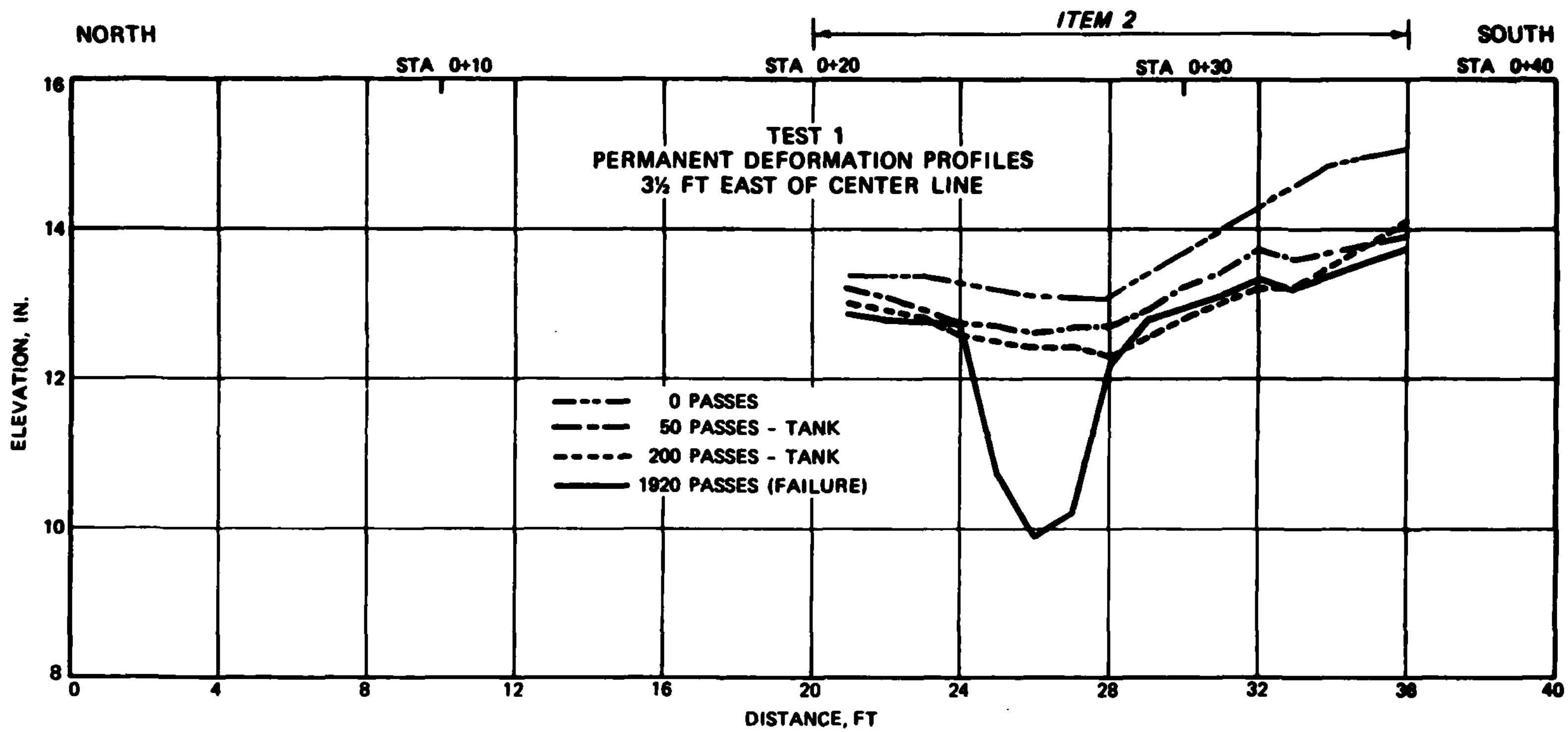


Figure 13. Permanent deformation profiles, test I, item 2

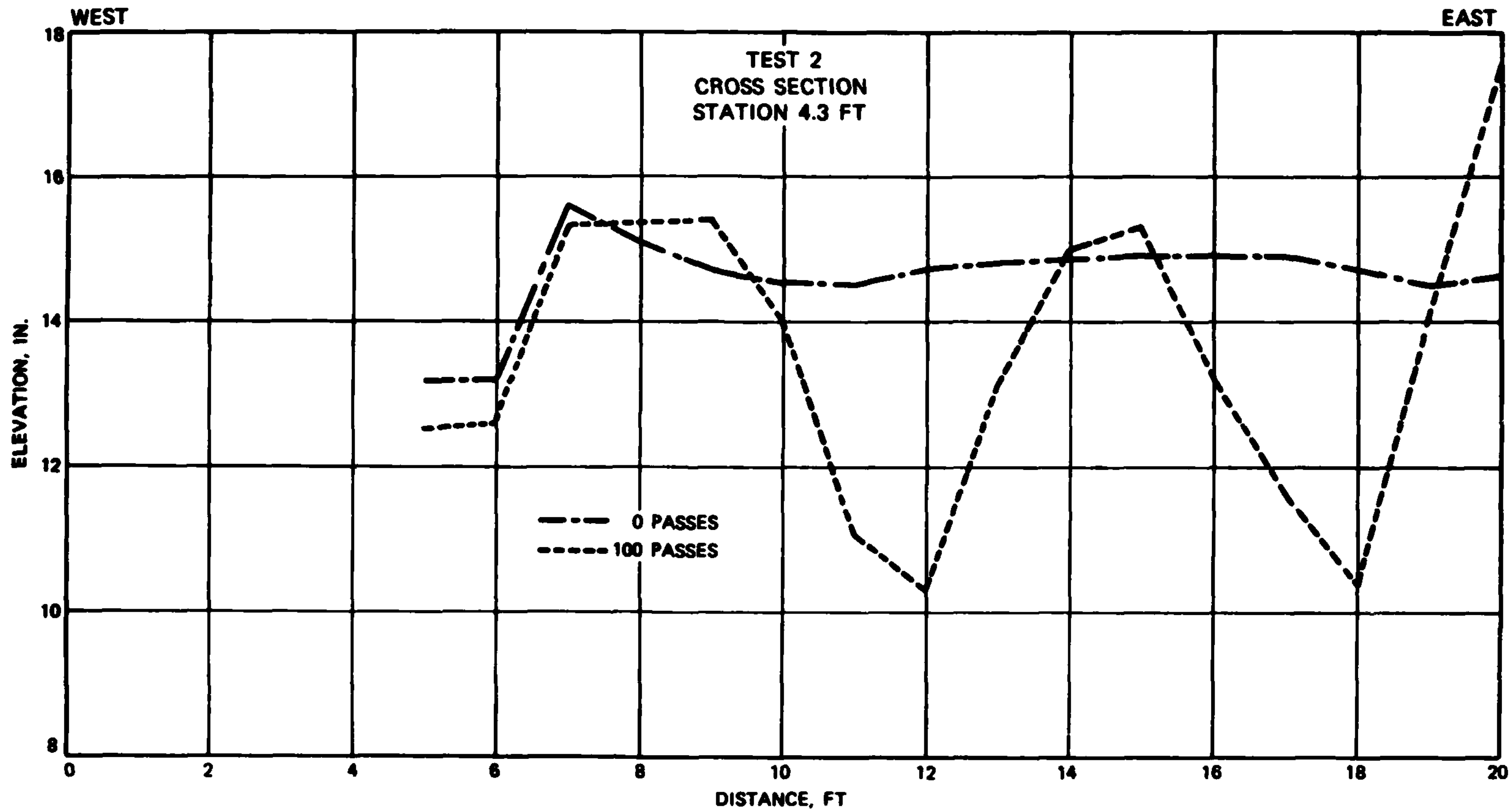


Figure 14. Cross sections, test II, item 2, sta 4.3 (truck traffic only)

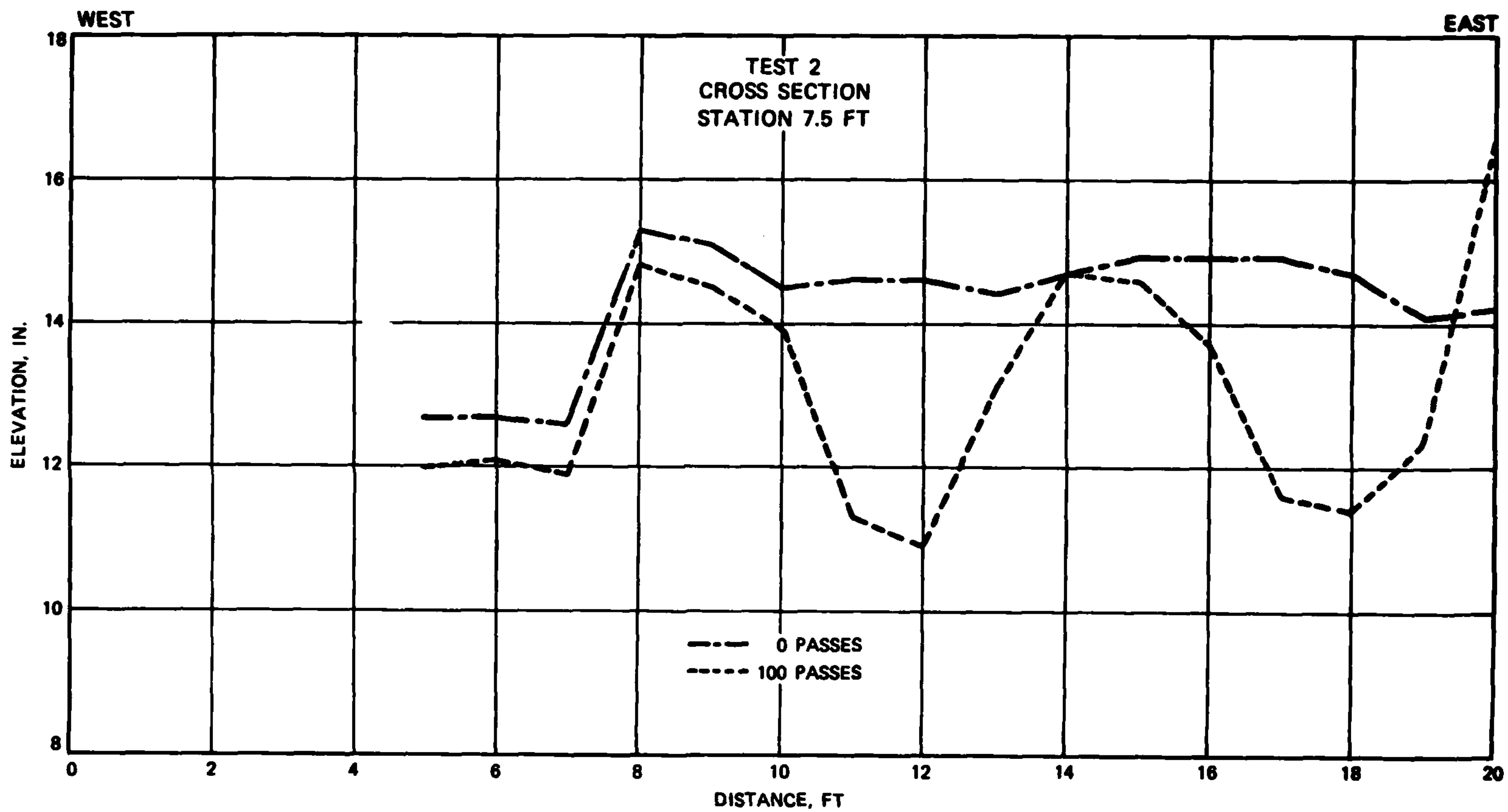


Figure 15. Cross sections, test II, item 2, sta 7.5 (truck traffic only)

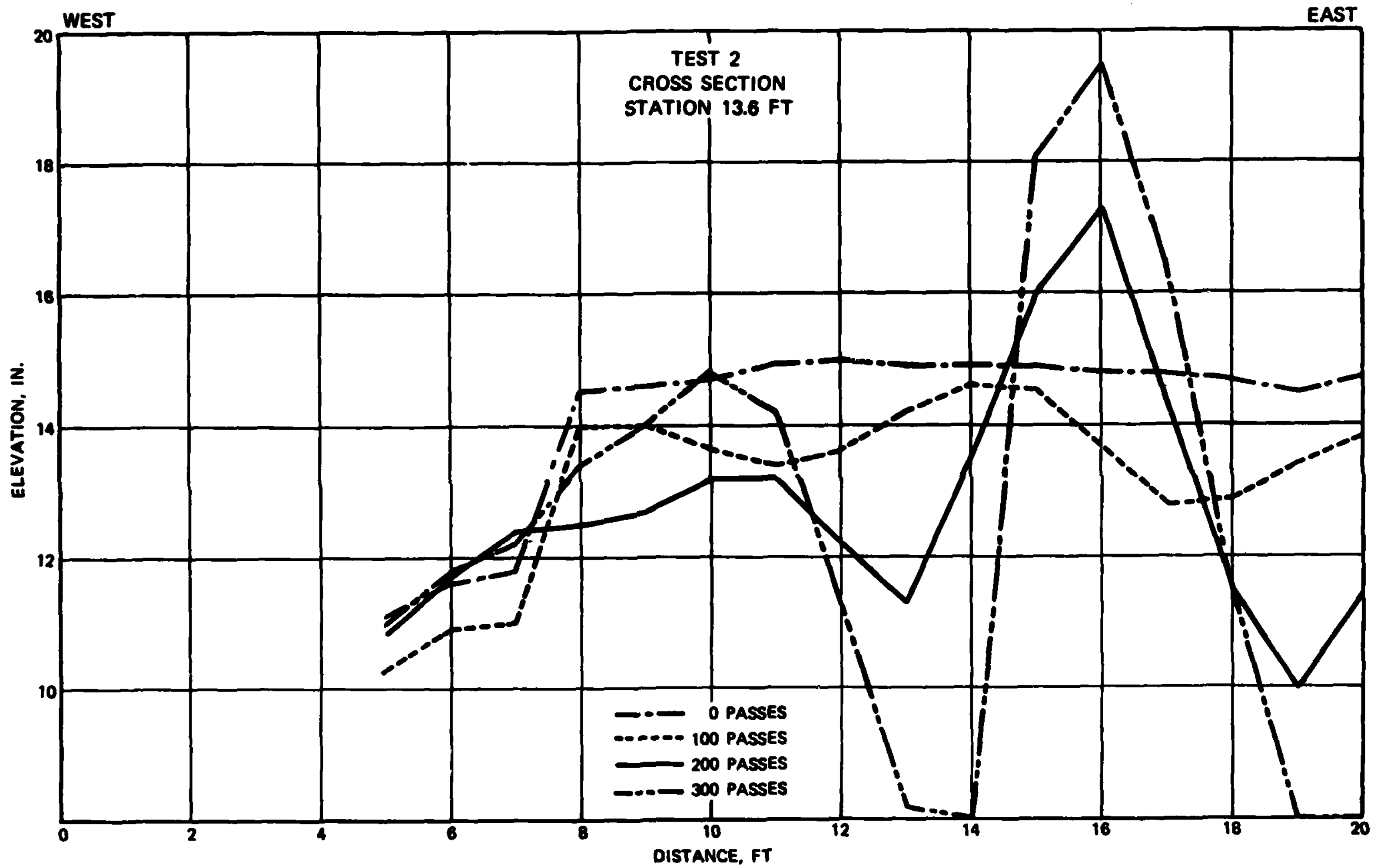


Figure 16. Cross sections, test II, item 2, sta 13.6 (truck traffic only)

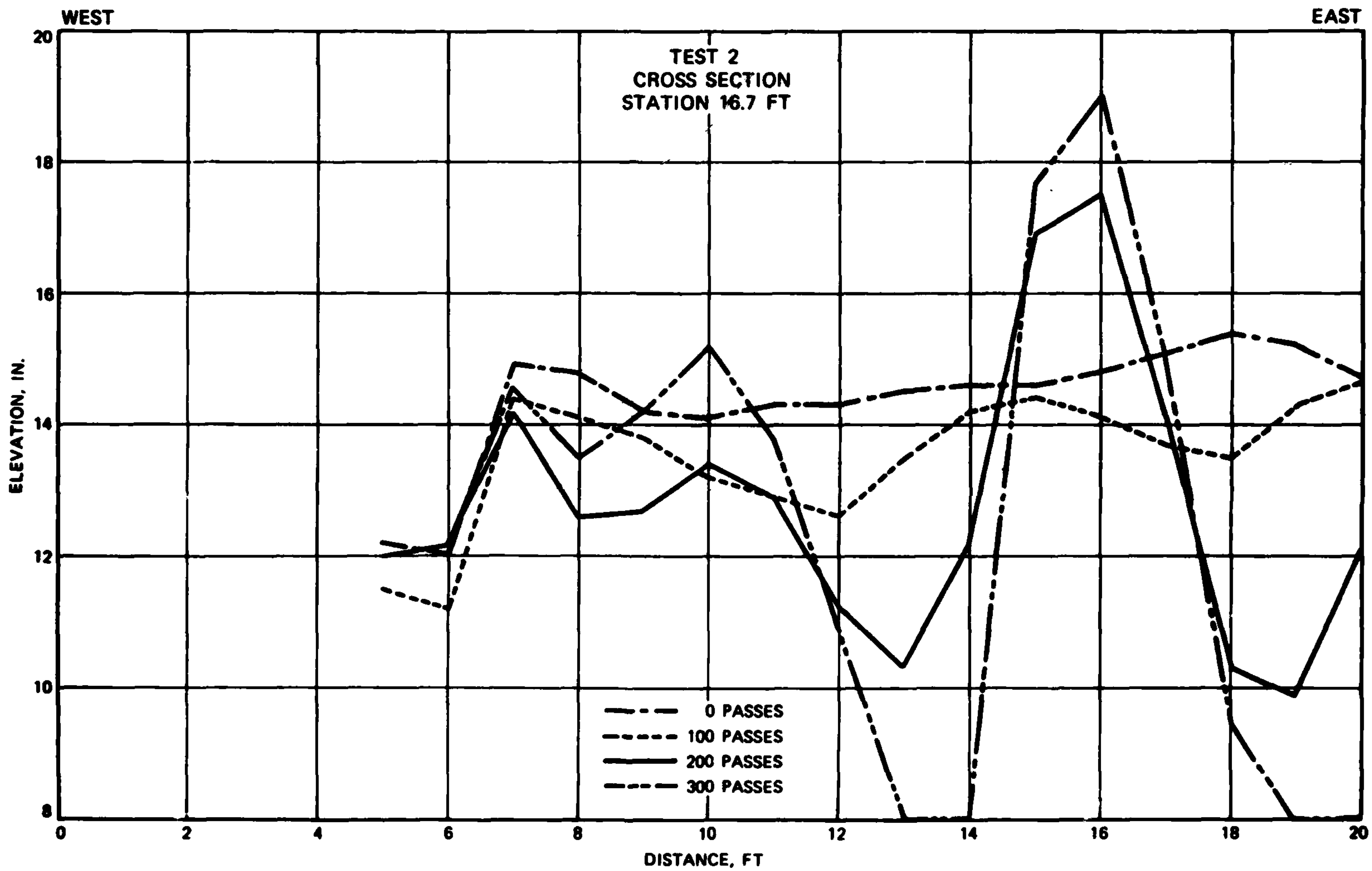


Figure 17. Cross sections, test II, item 1, sta 16.7 (truck traffic only)

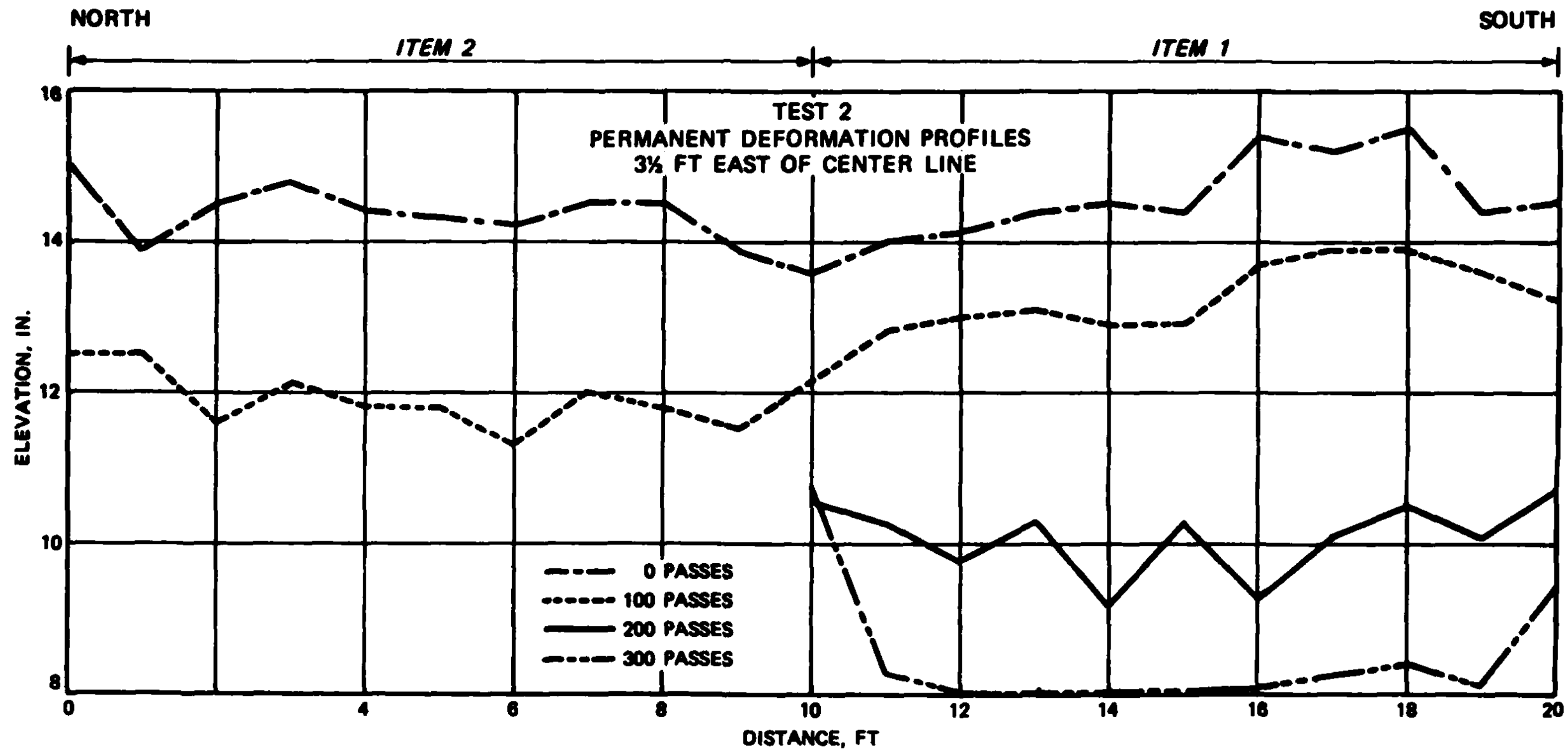


Figure 18. Permanent deformation profiles, test II, items 1 and 2, 3.5 ft east of center line (truck traffic only)

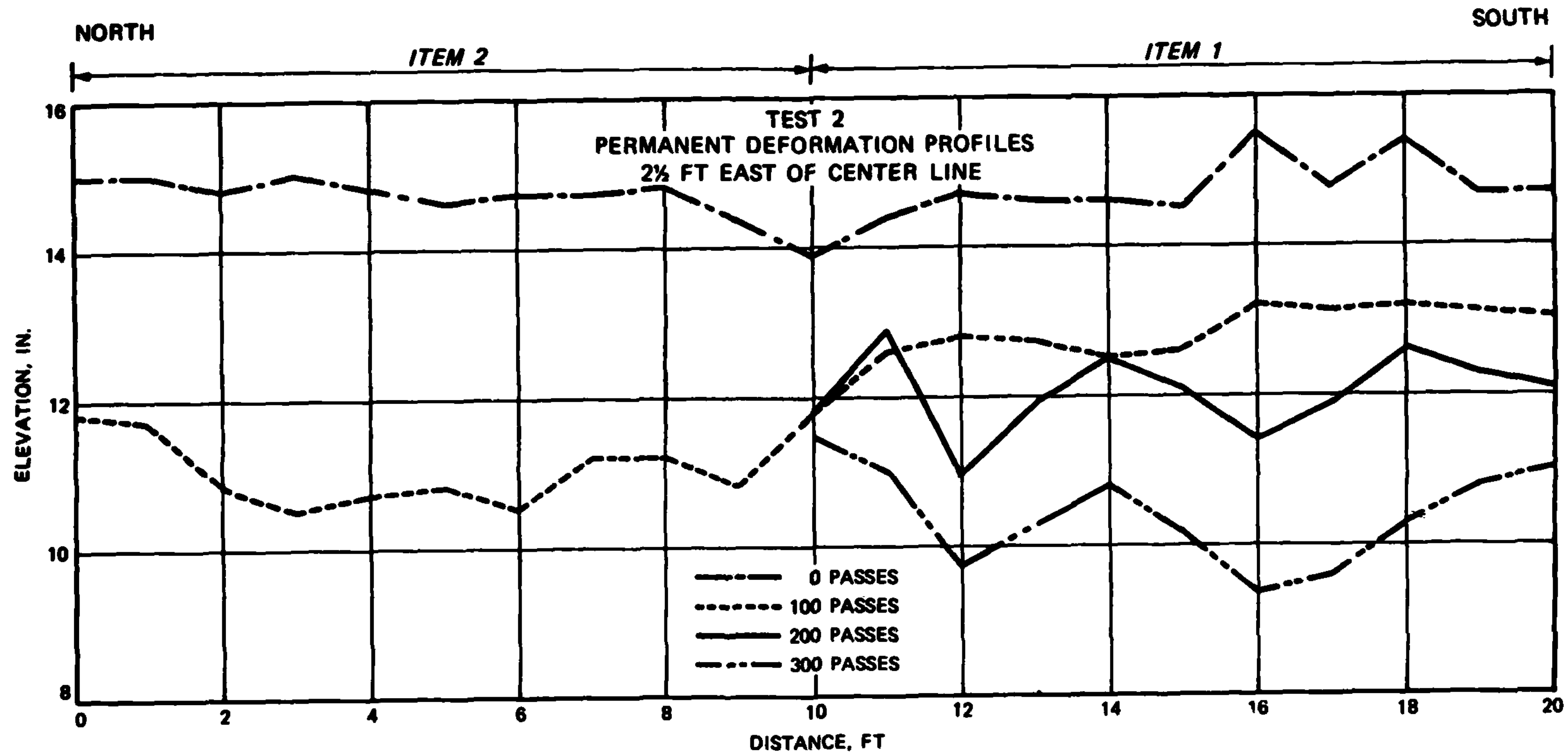


Figure 19. Permanent deformation profiles, test II, items 1 and 2, 2.5 ft east of center line (truck traffic only)

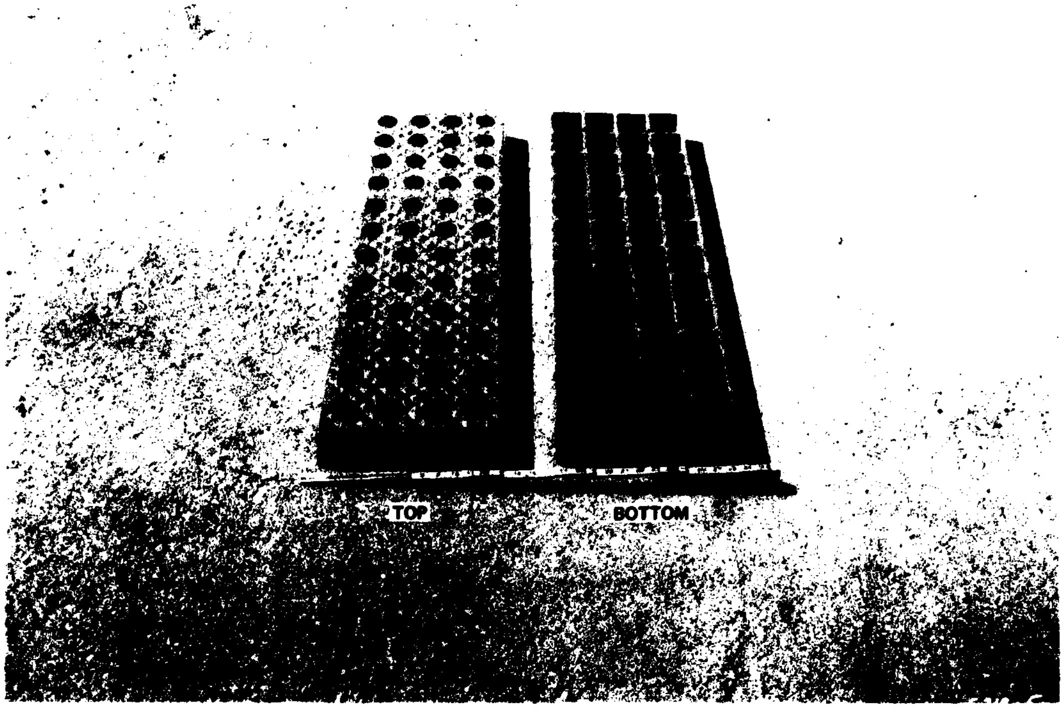


Photo 1. Sod Saver Blocks (showing top and bottom), as received from manufacturer

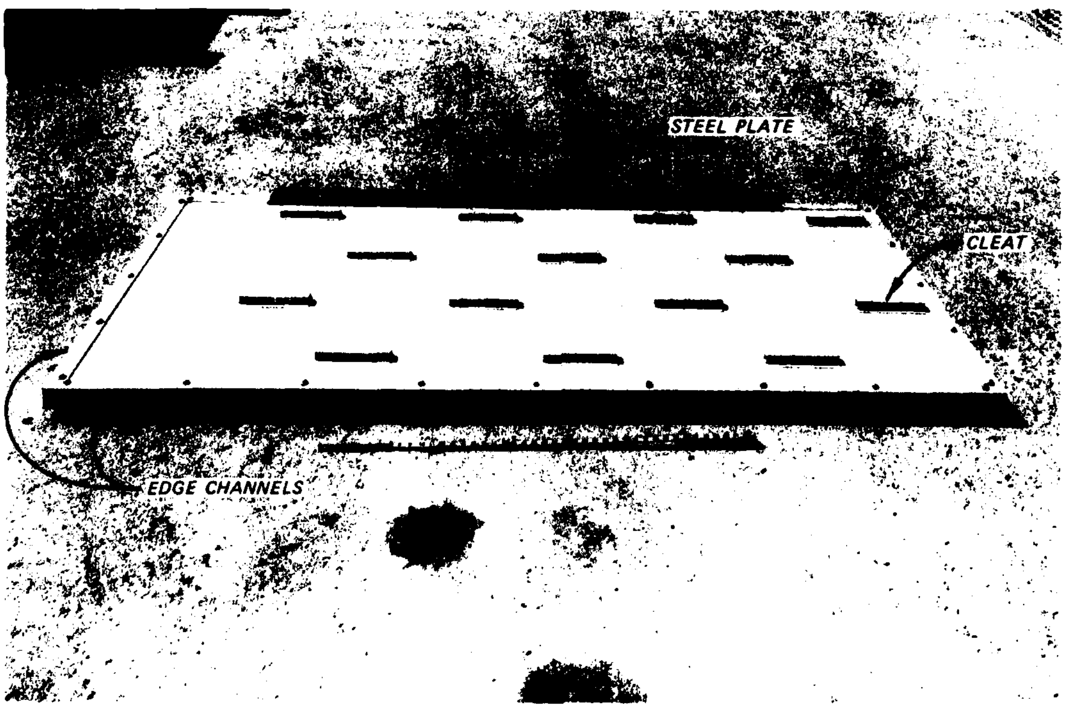


Photo 2. M. C. Gill panel (Note: The 5-in.-wide plate attached to one edge was not included by manufacturer.)

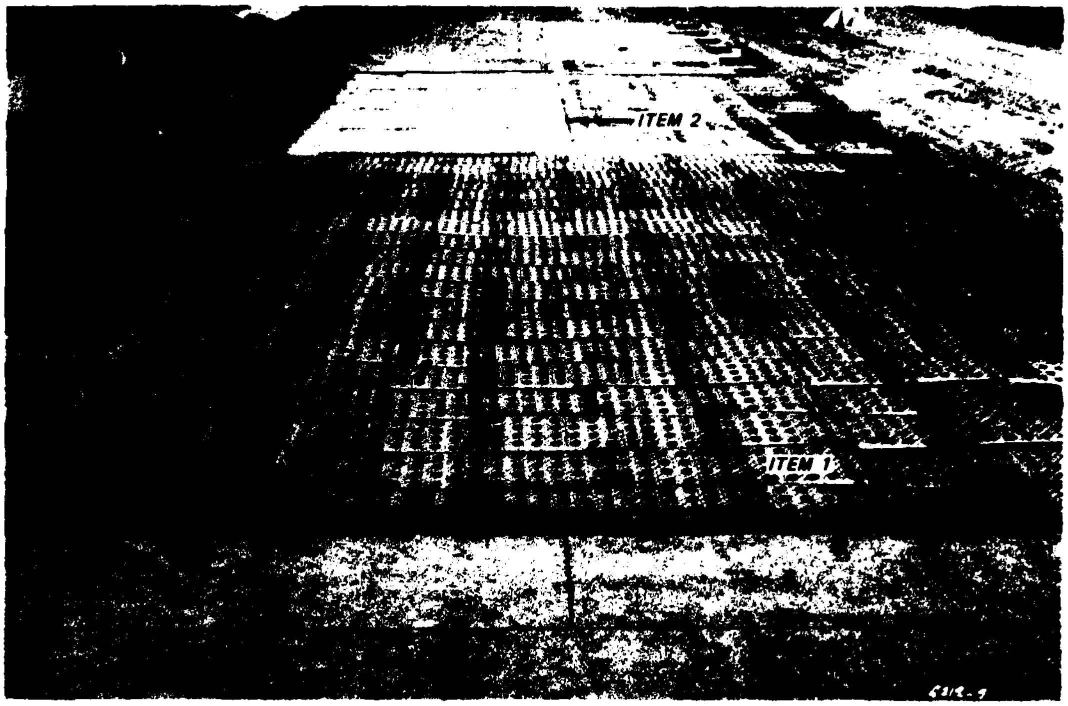


Photo 3. General view of test section before traffic, showing Sod Saver Blocks on item 1 and M. C. Gill panels on item 2, test I

Photo 4. Bulldozer spreading heavy clay in test section

Photo 5. General view of test section subgrade before placing test materials

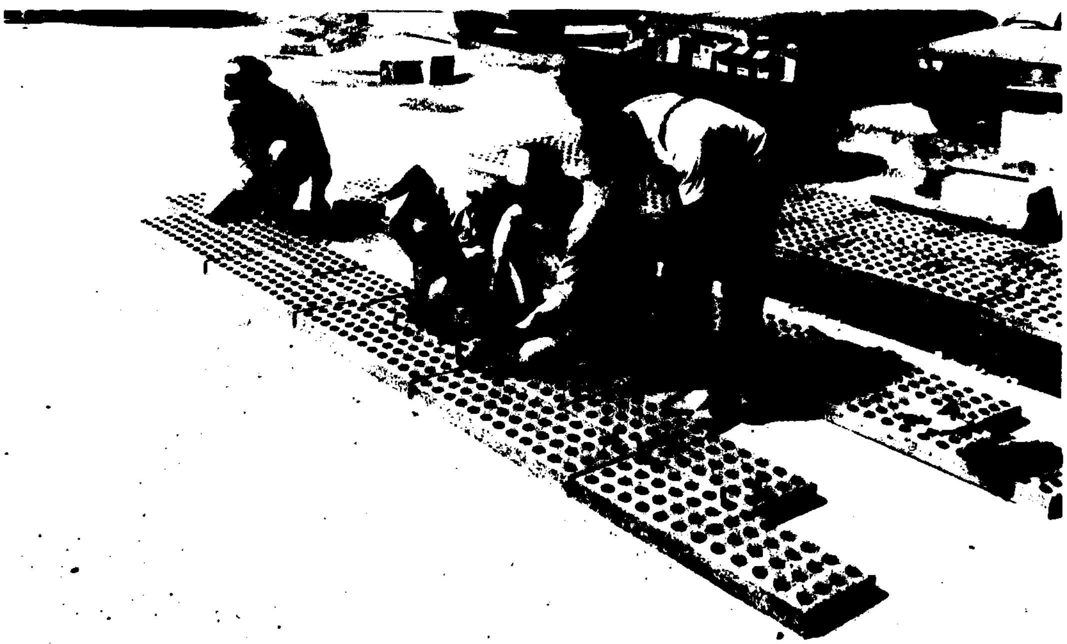


Photo 6. Assembling Sod Saver Blocks with plastic straps, test I

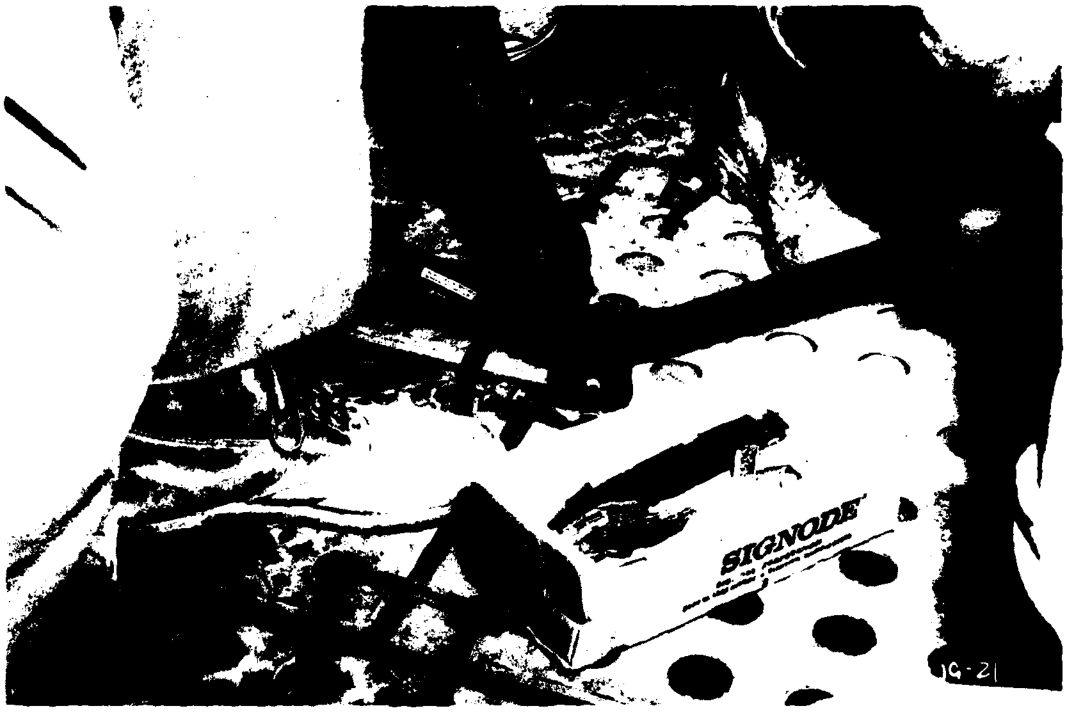


Photo 7. Attaching plastic straps with crimping tool, test I

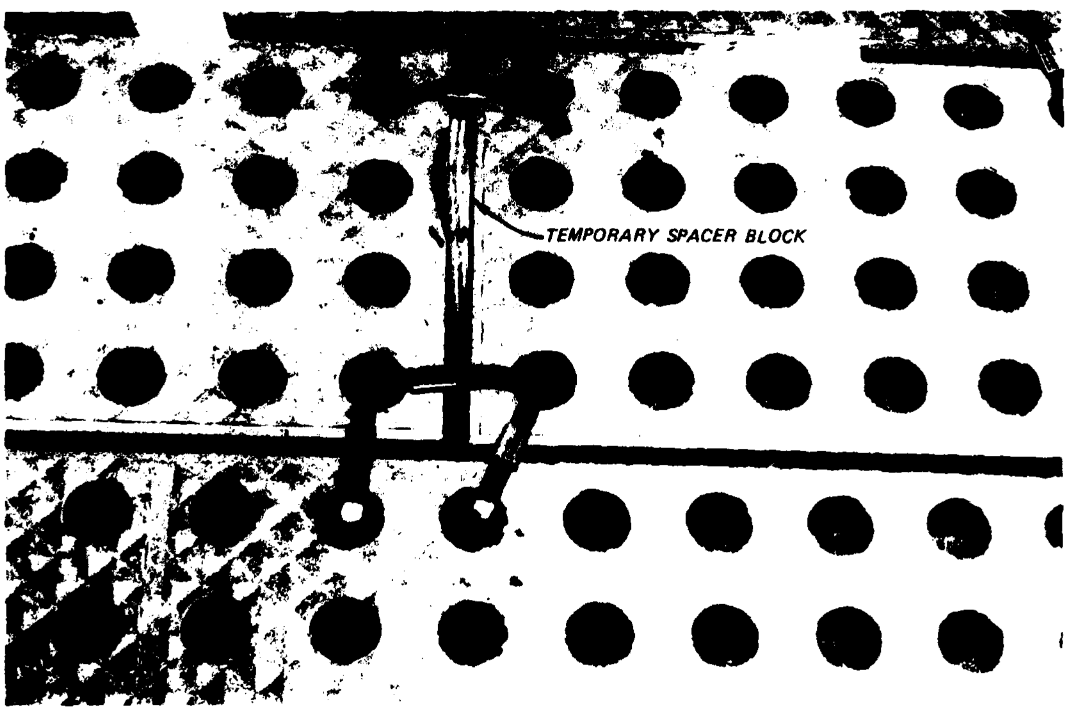


Photo 8. Close-up of a typical completed joint of Sod Saver Blocks, test II

Photo 9. Two runs of Sod Saver Blocks being placed on test section, test I

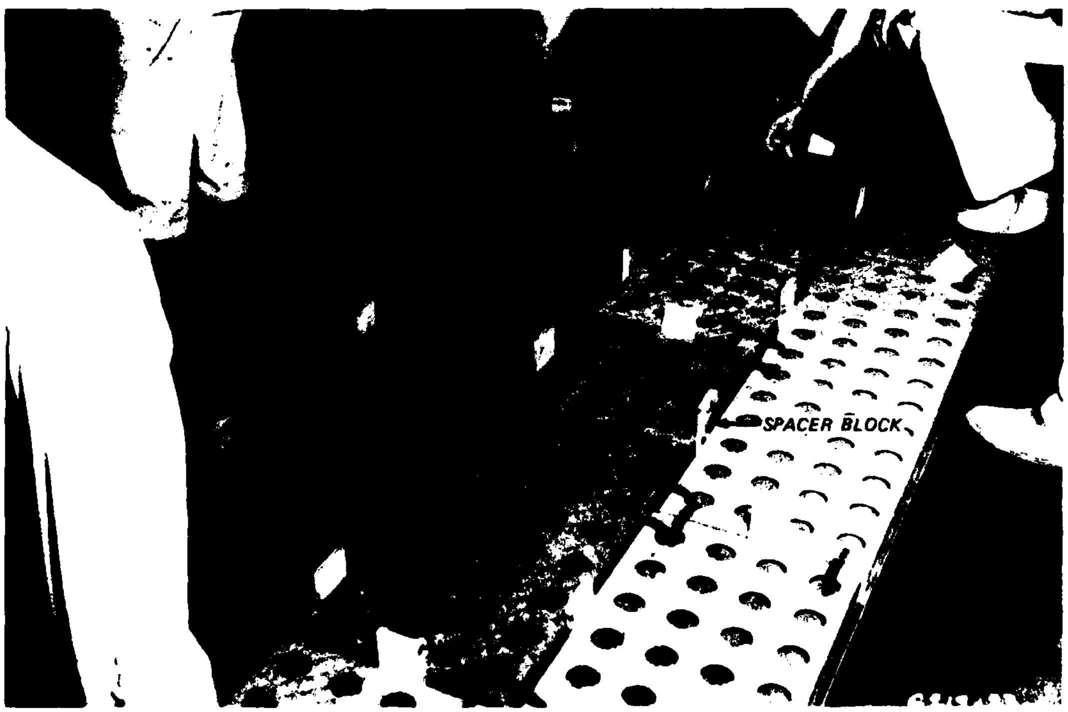


Photo 10. Four runs of Sod Saver Blocks in place before attaching plastic straps (Note spacer blocks to allow for hinging action, test I.)

Photo 11. Typical connection of M. C. Gill panels

Photo 12. The 5-ton M54 cargo truck; gross load, 40,000 lb

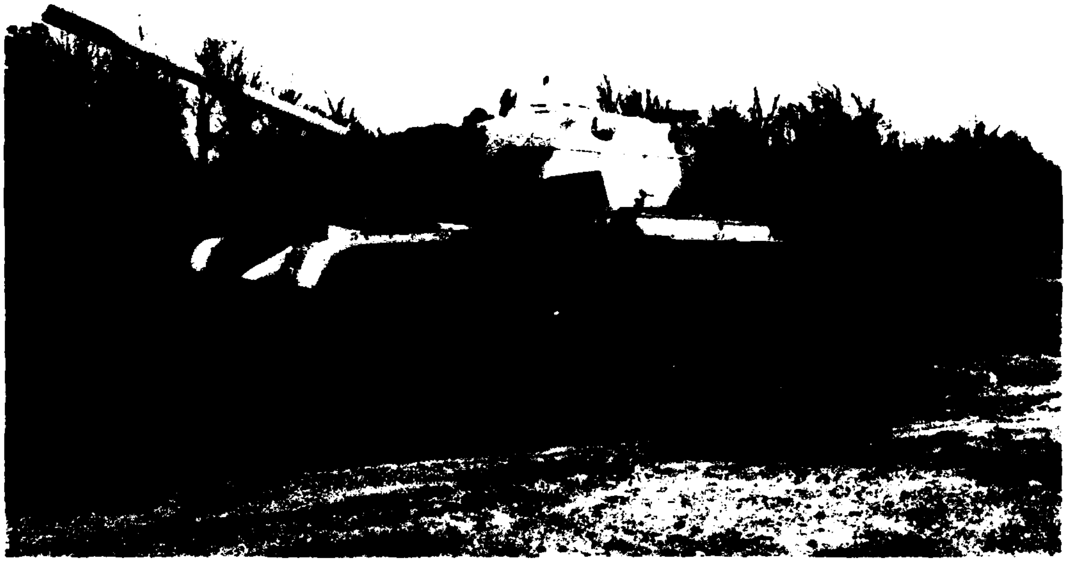


Photo 13. M8A1 tank; gross load, 106,000 lb

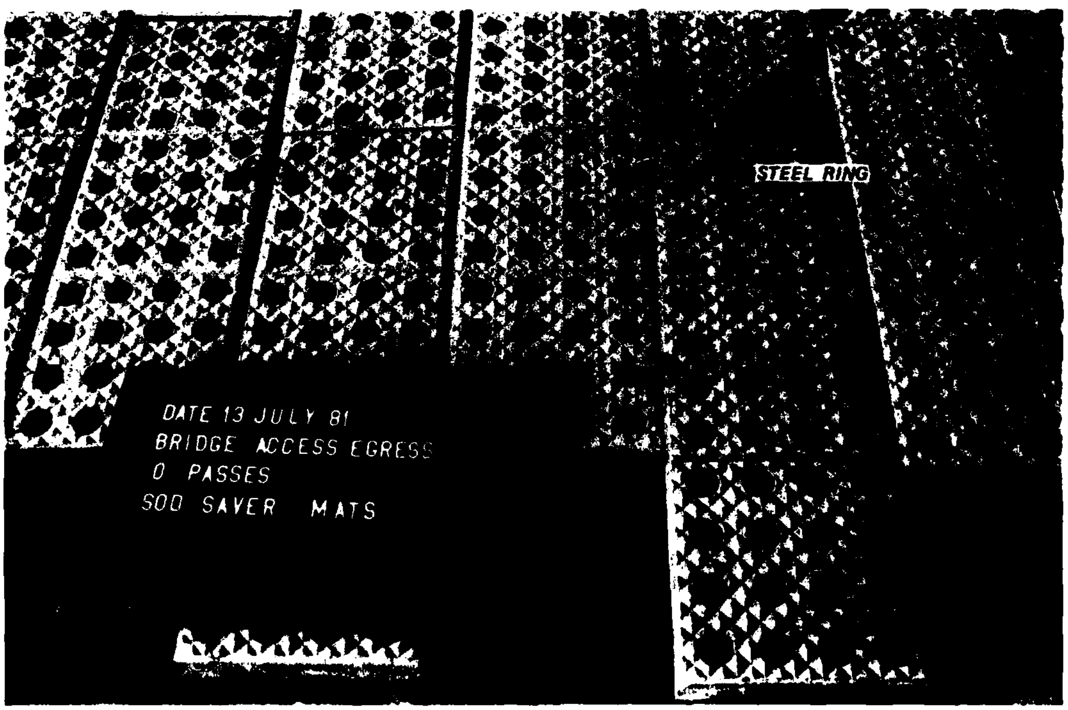


Photo 14. Close-up of Sod Saver Blocks on test section before traffic, showing staggered pattern and location of steel rings, test II

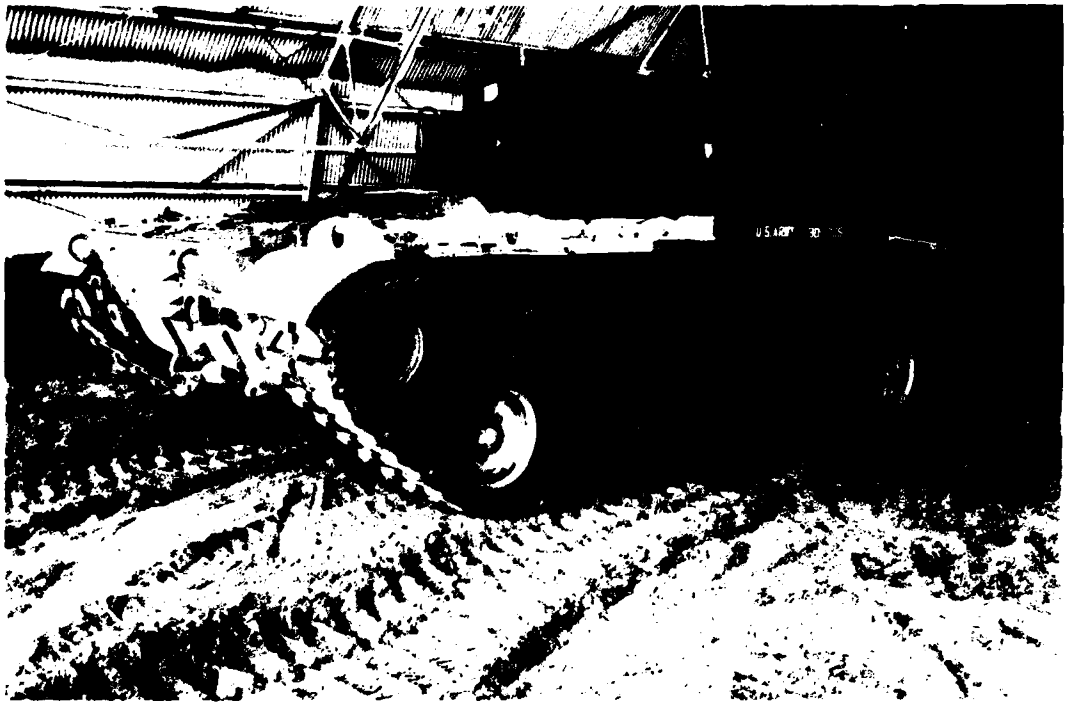


Photo 15. M8A1 tank fitted with special weights; gross load, 140,000 lb

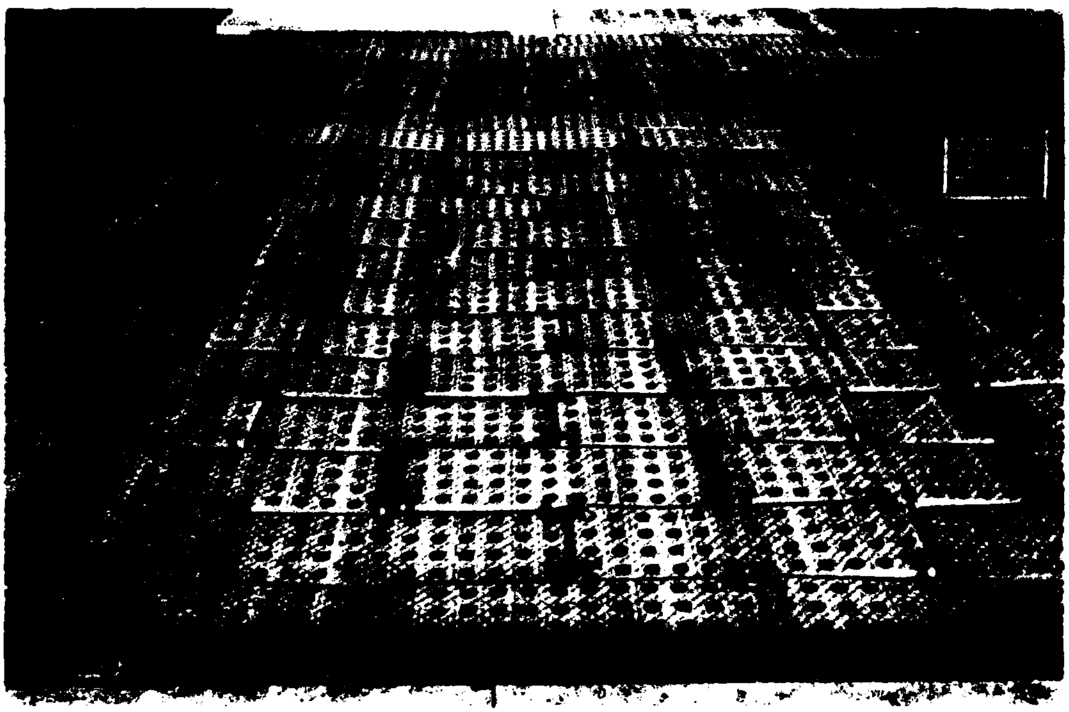


Photo 16. General view of item 1 covered with Sod Saver Blocks prior to traffic

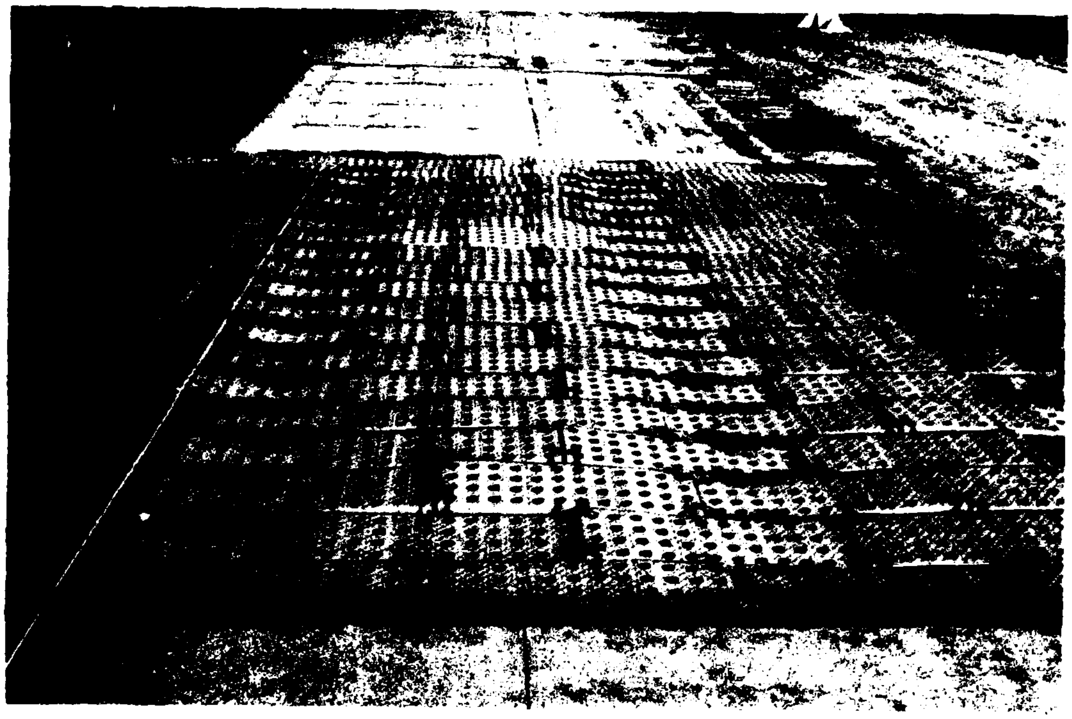


Photo 17. Items 1 and 2 after 10 passes with 5-ton truck

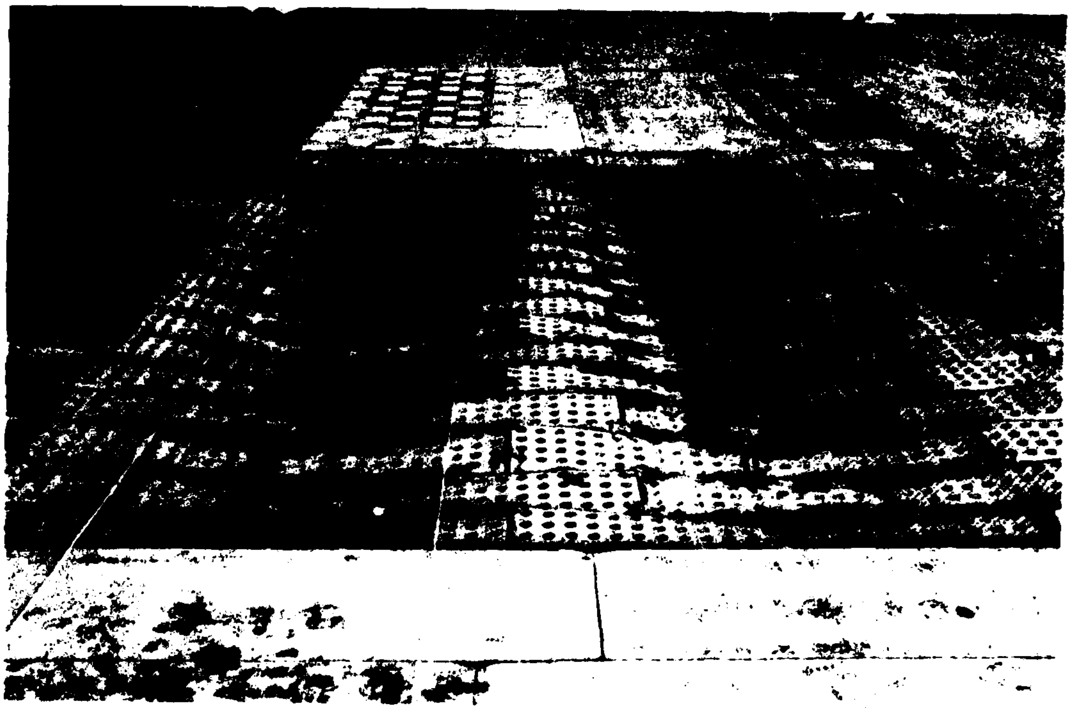


Photo 18. Items 1 and 2 after 25 passes with 5-ton truck

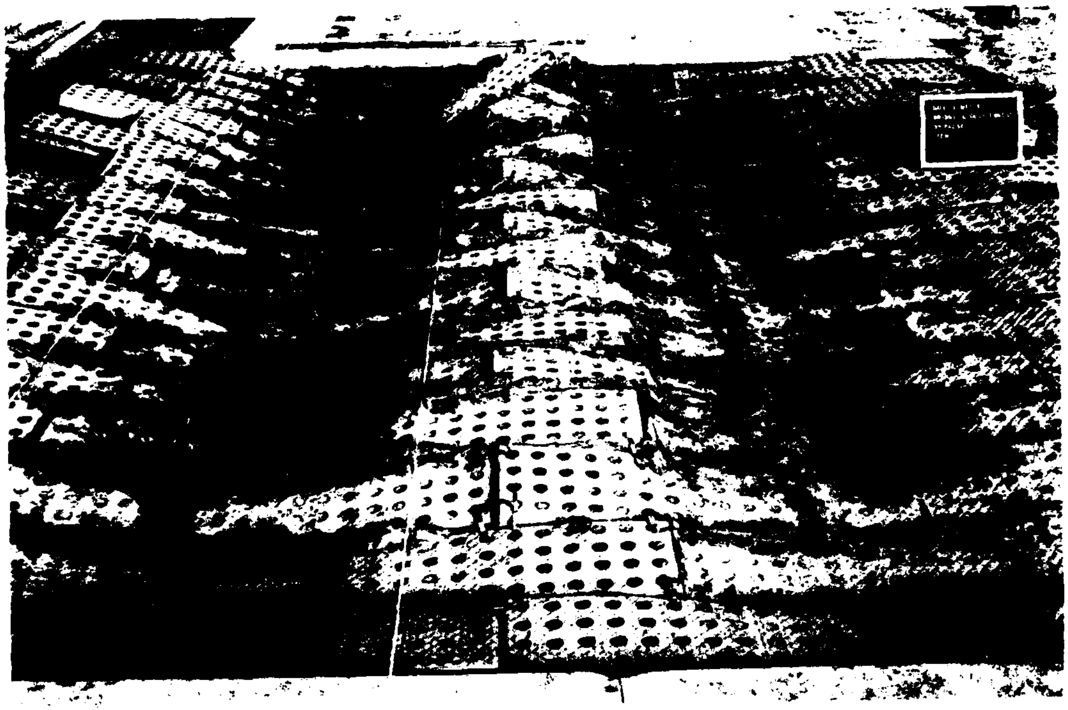


Photo 19. Close-up of item 1 (failed) after 39 passes with 5-ton truck

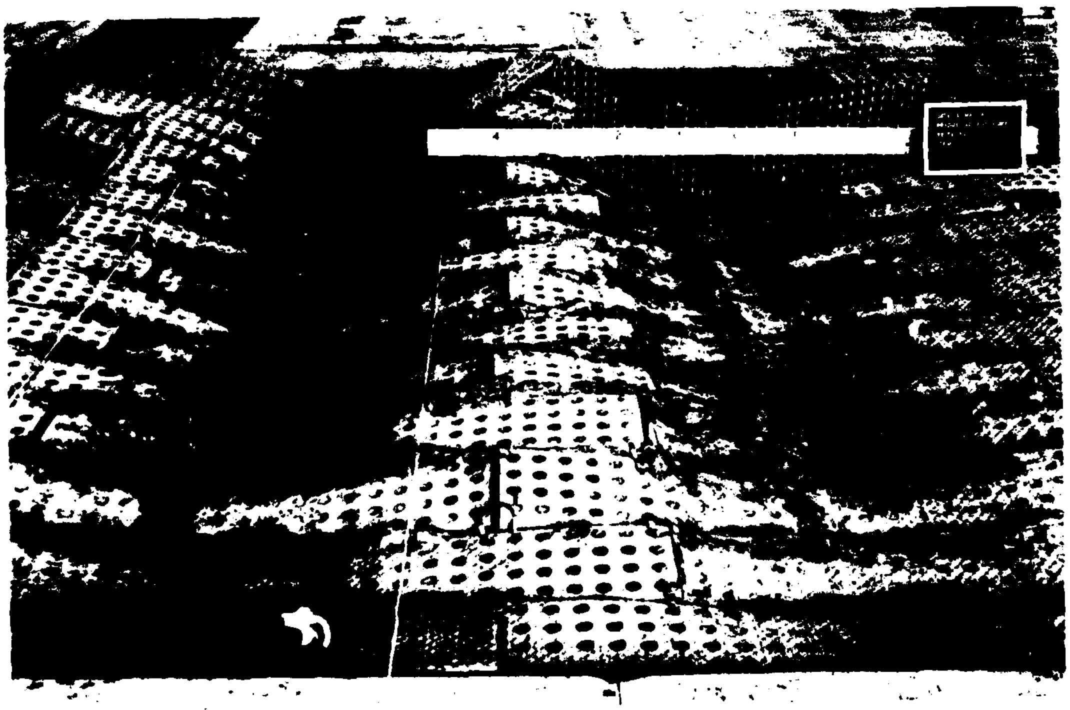


Photo 20. Maximum deflection in west wheel path of item 1 (failed) after 39 passes with 5-ton truck

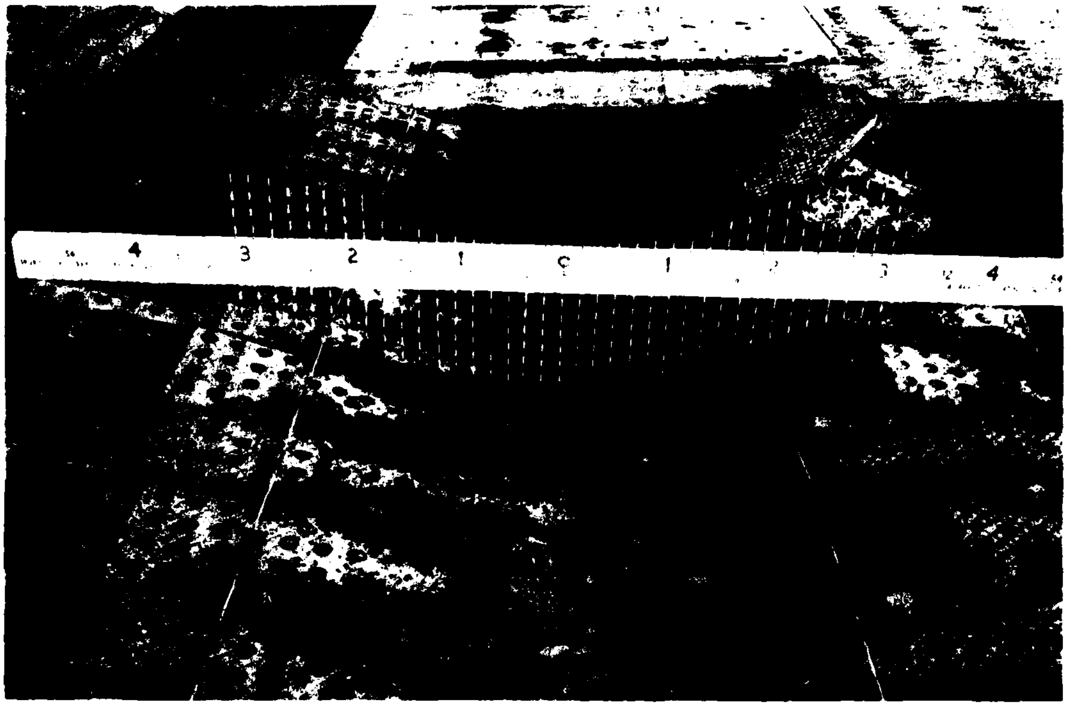


Photo 21. Maximum deflection in east wheel path of item 1 (failed) after 39 passes with 5-ton truck

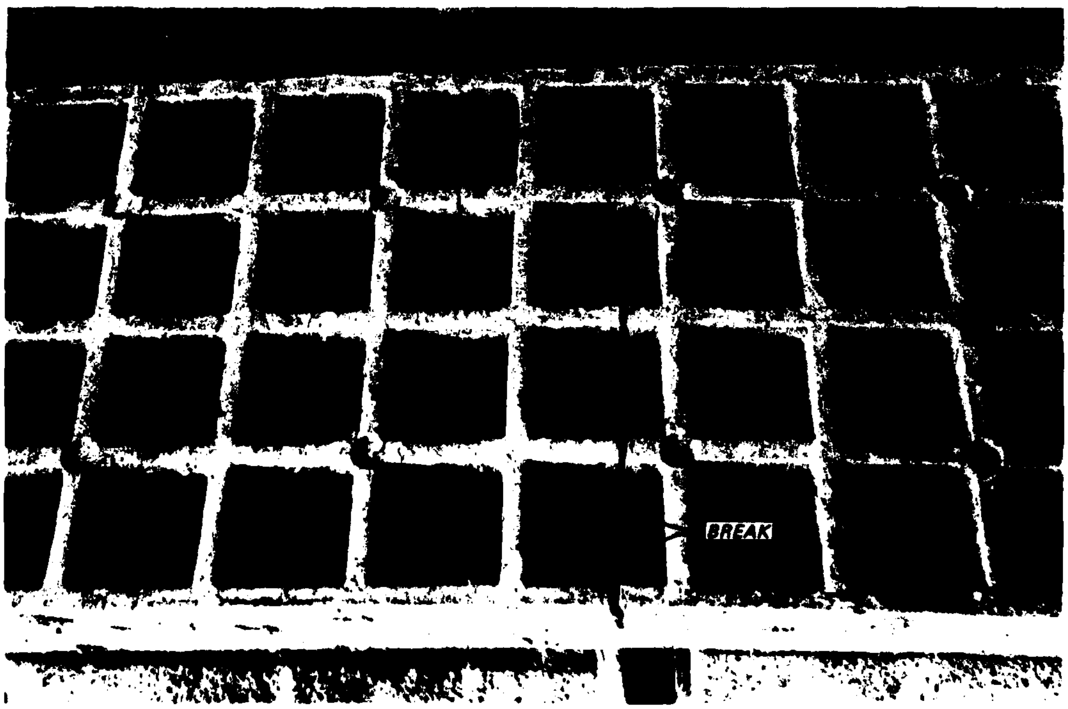


Photo 22. Close-up of break in bottom of Sod Saver Block at failure after 39 passes with 5-ton truck

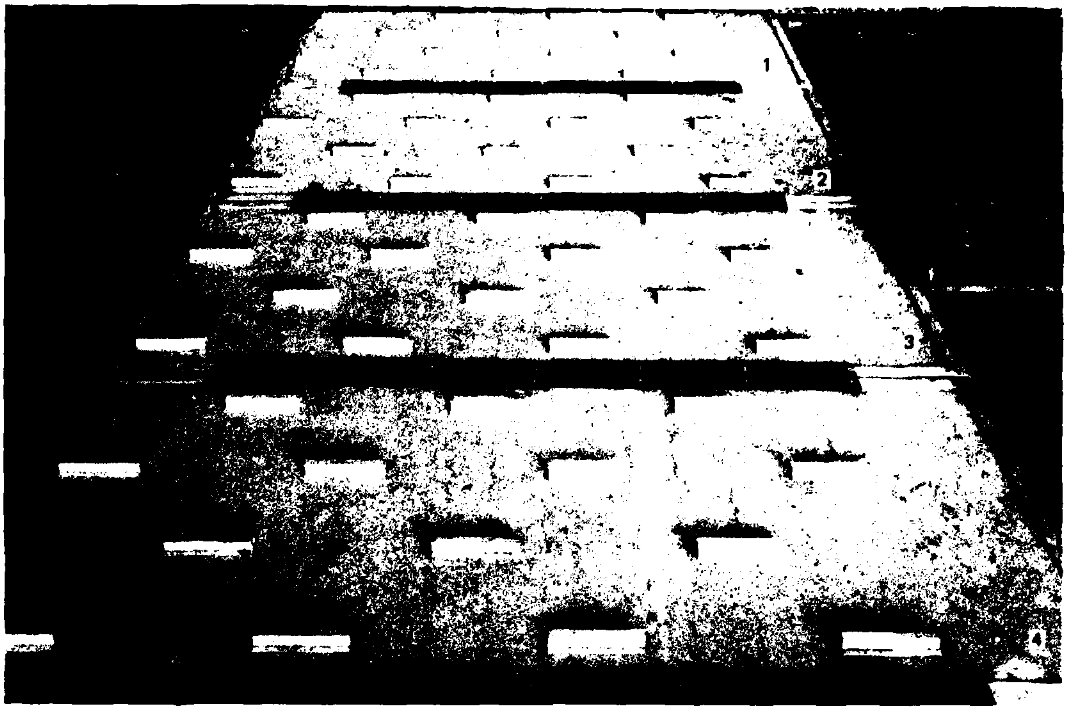


Photo 23. Close-up of M. C. Gill panels on item 2 before traffic

Photo 24. M. C. Gill panels in item 2 after 200 passes with the 5-ton truck

Photo 25. M. C. Gill panels in item 2 after 1148 passes with the 5-ton truck

Photo 26. Cleat failure and approximately 16-in. tear in top skin of M. C. Gill panel 3 after 1148 passes with 5-ton truck

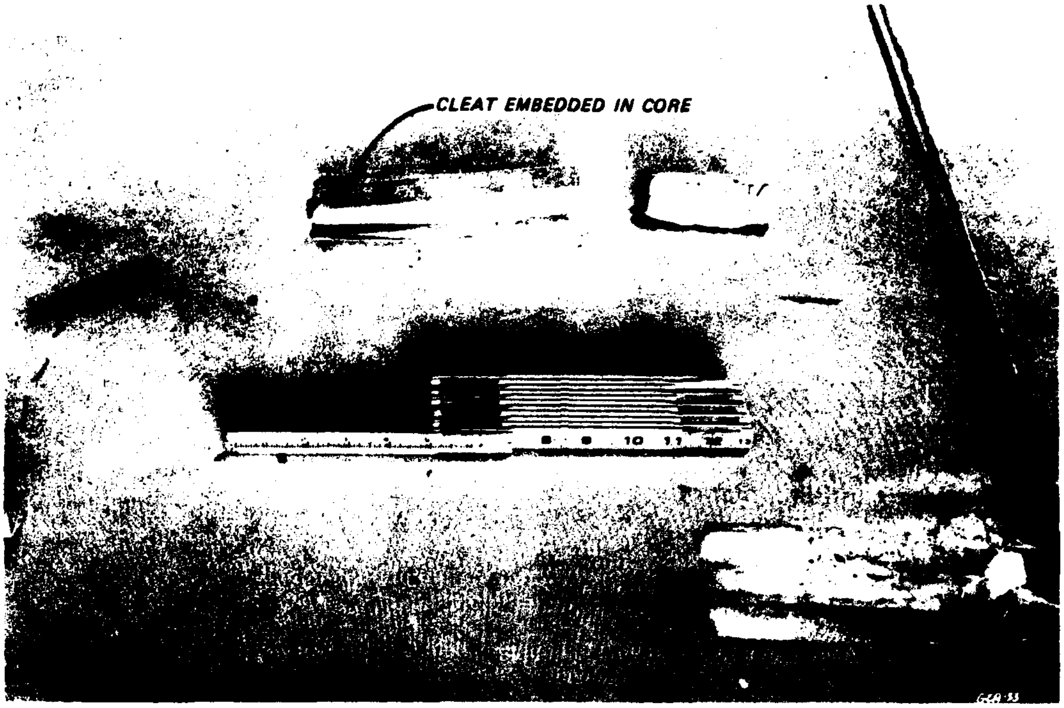


Photo 27. Cleat embedded in core of M. C. Gill panel 4 after 1 pass with M48A1 Tank; gross load, 106,000 lb

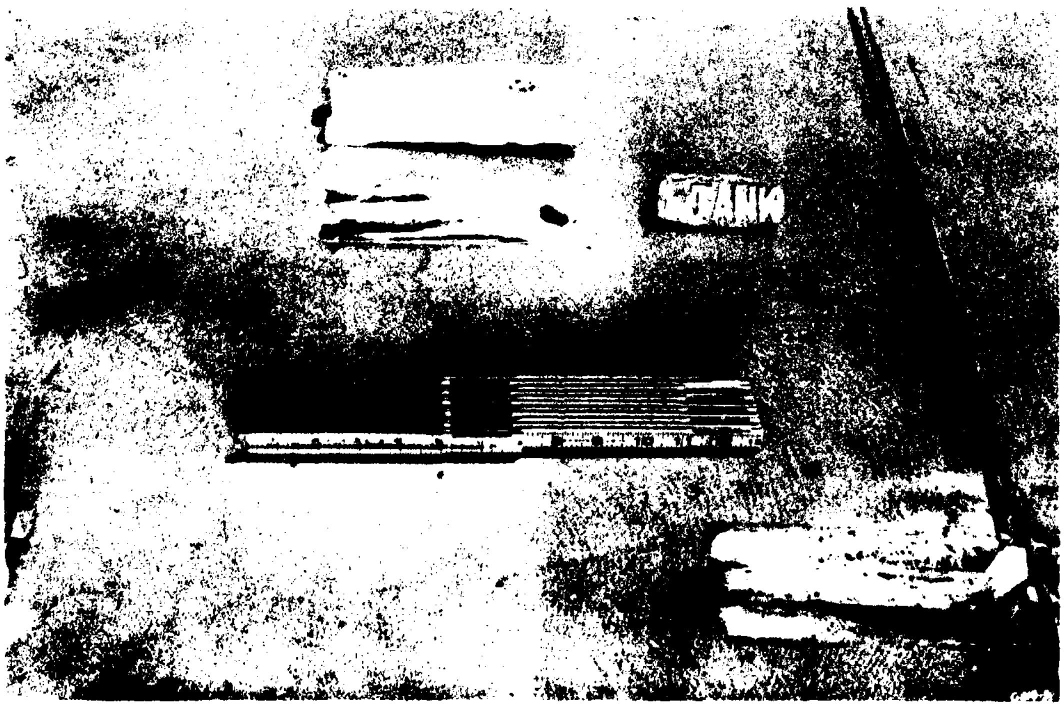


Photo 28. Embedded cleat removed from core of M. C. Gill panel 4

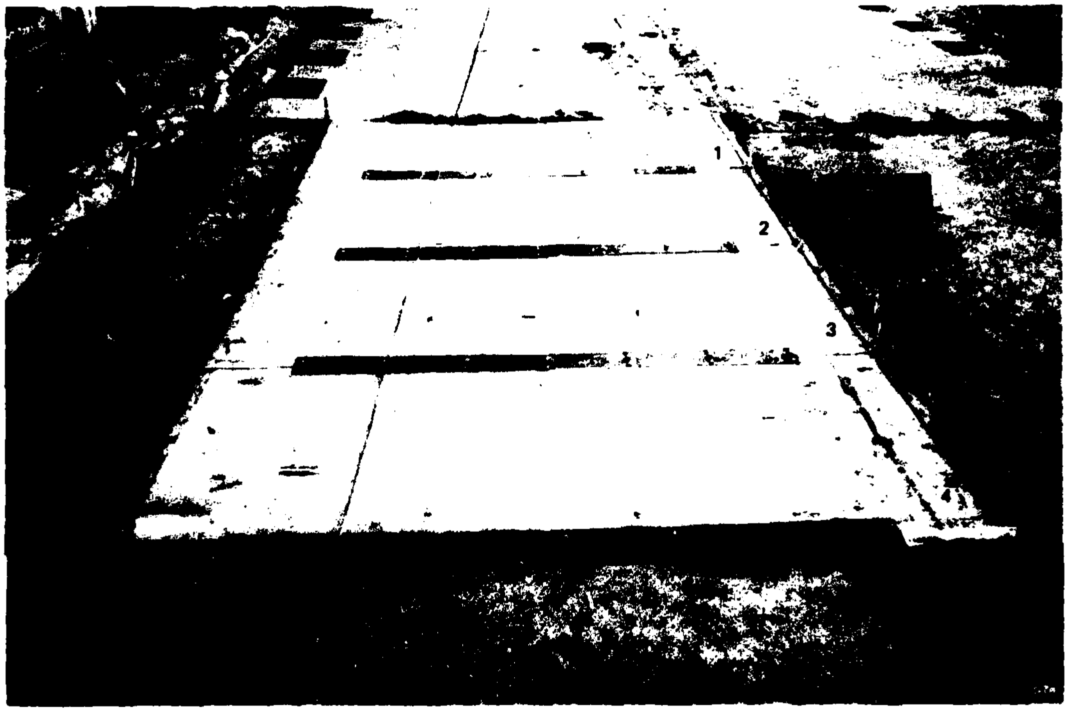


Photo 29. General view of item 2, showing M. C. Gill panel after 50 passes with the M48A1 tank, test 1

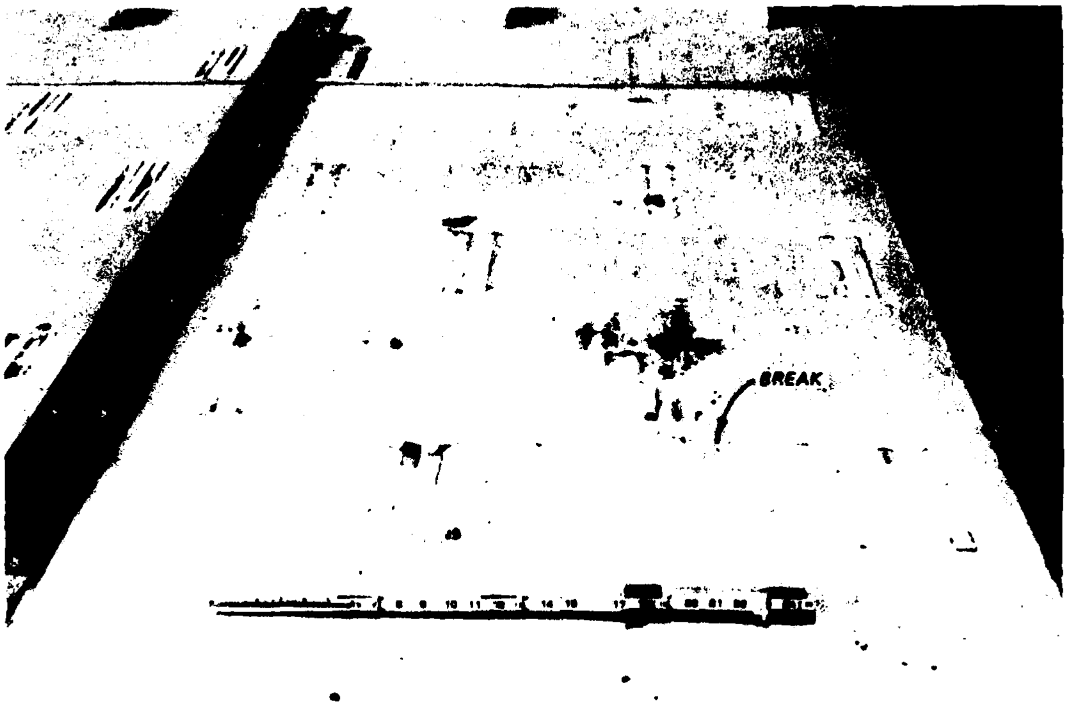


Photo 30. Break in M. C. Gill panel after 50 passes with M48A1 tank

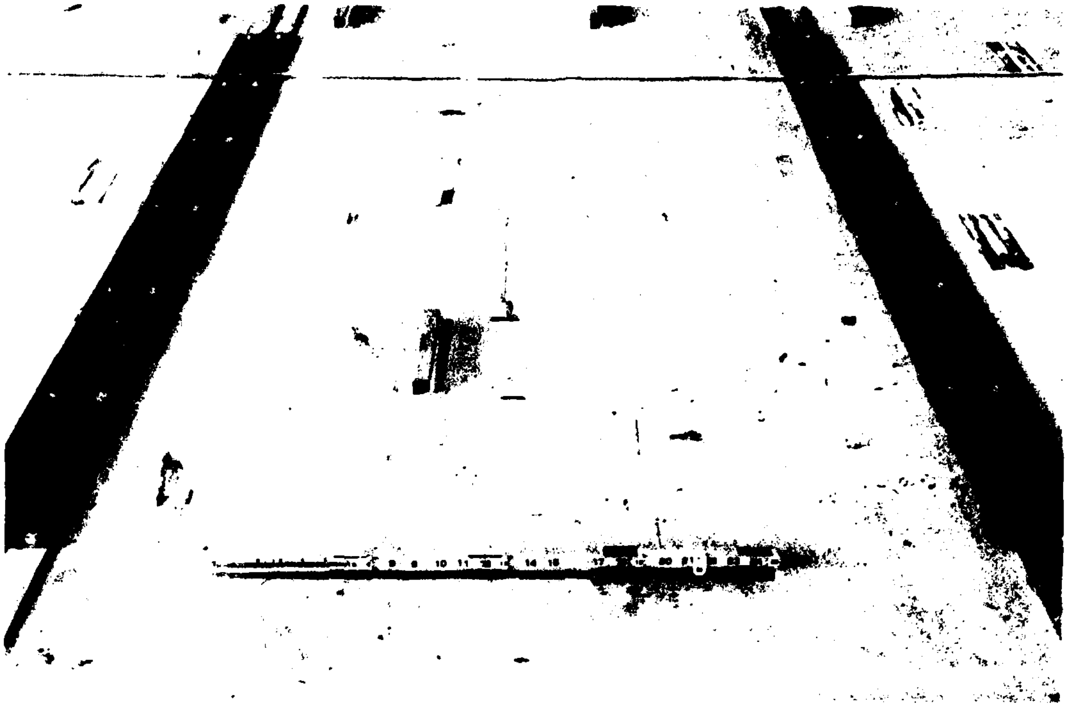


Photo 31. Breaks in panel 3 after 50 passes with M48A1 tank

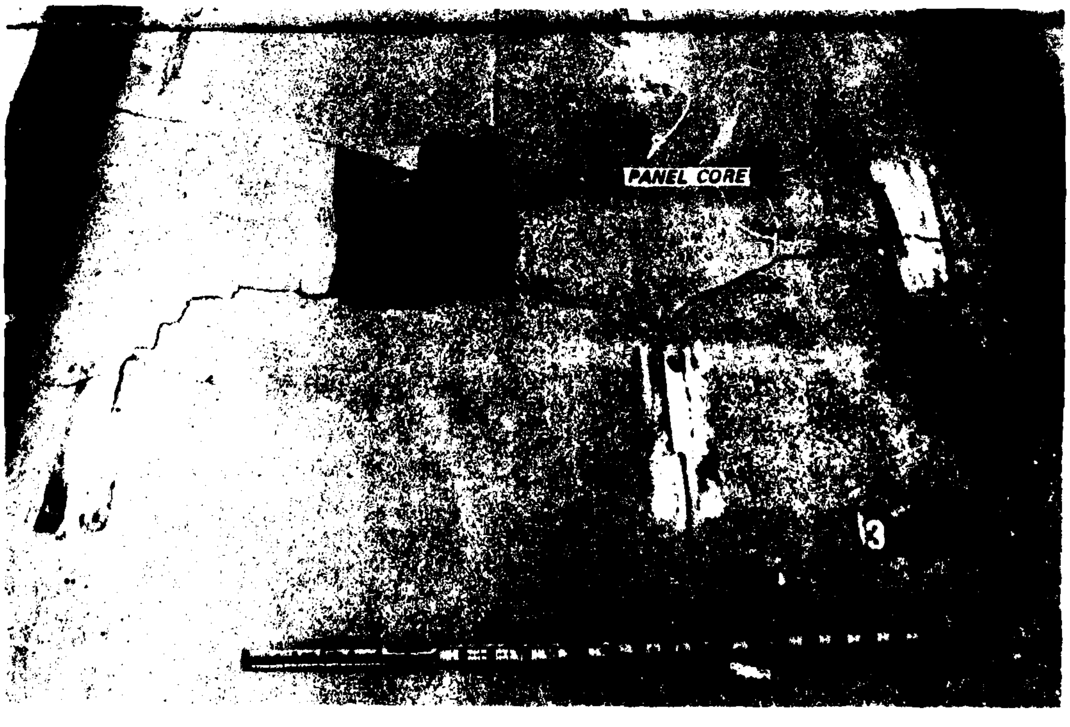


Photo 32. Breaks in panel 3 after 120 passes with M48A1 tank

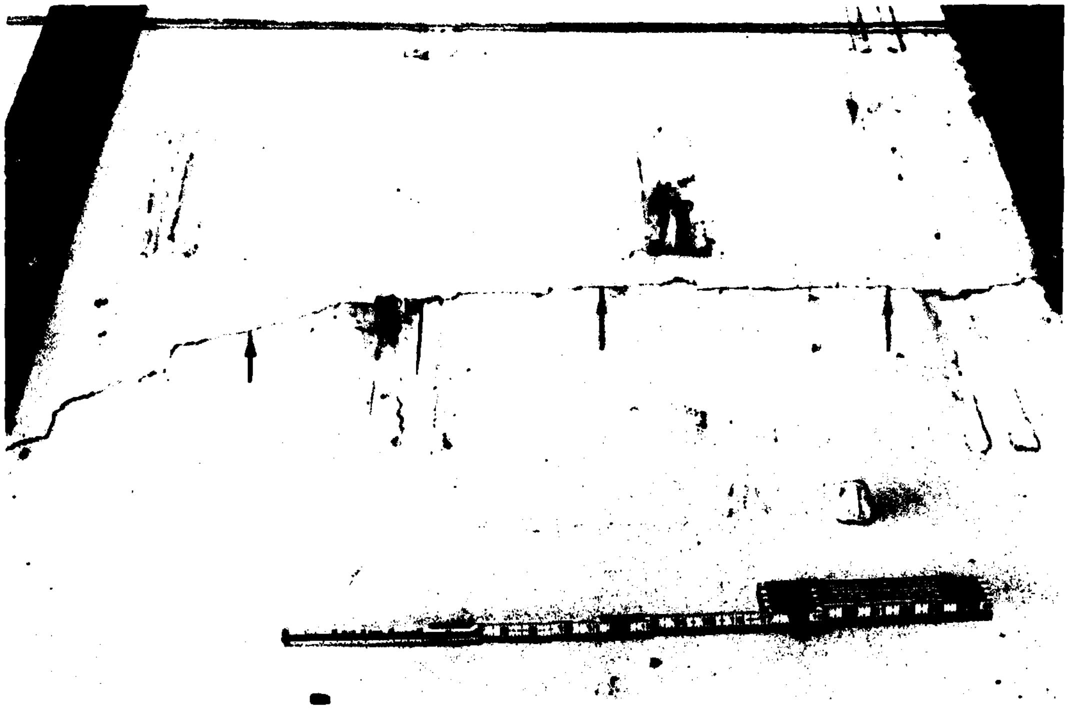


Photo 33. Break in panel 1 after 168 passes with M48A1 tank

Photo 34. General view of item 2 after 200 passes with M48A1 tank and 1200 passes with the 5-ton truck, test I

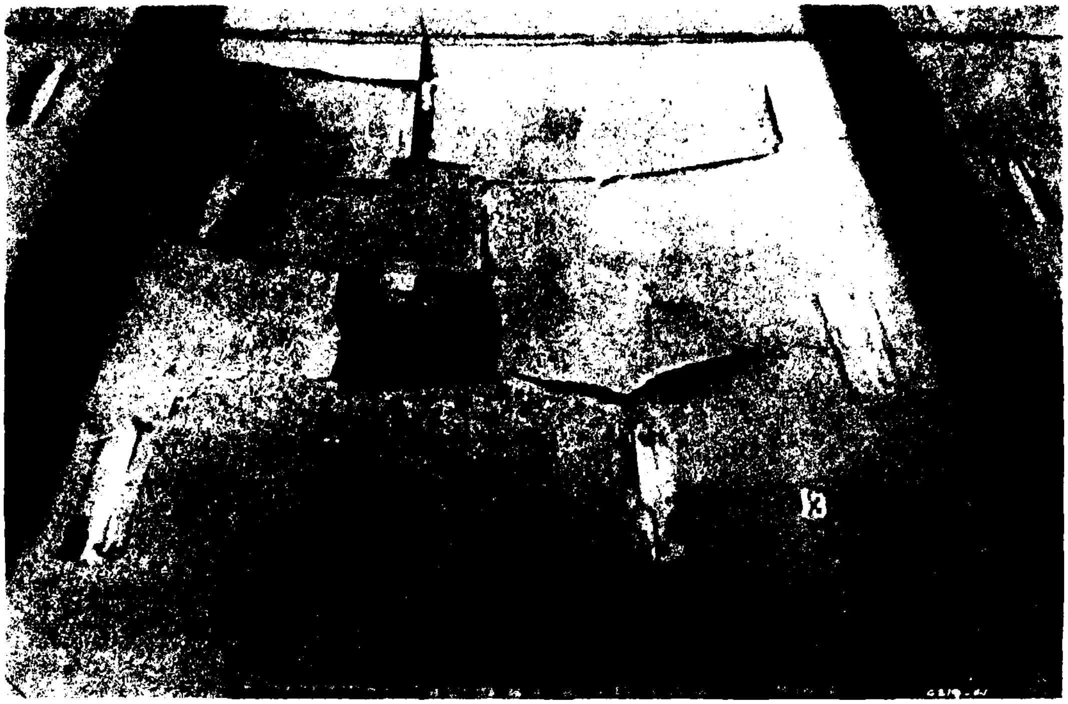


Photo 35. Panel 3 (failed) after 1920 passes
(200 tank and 1720 truck passes)

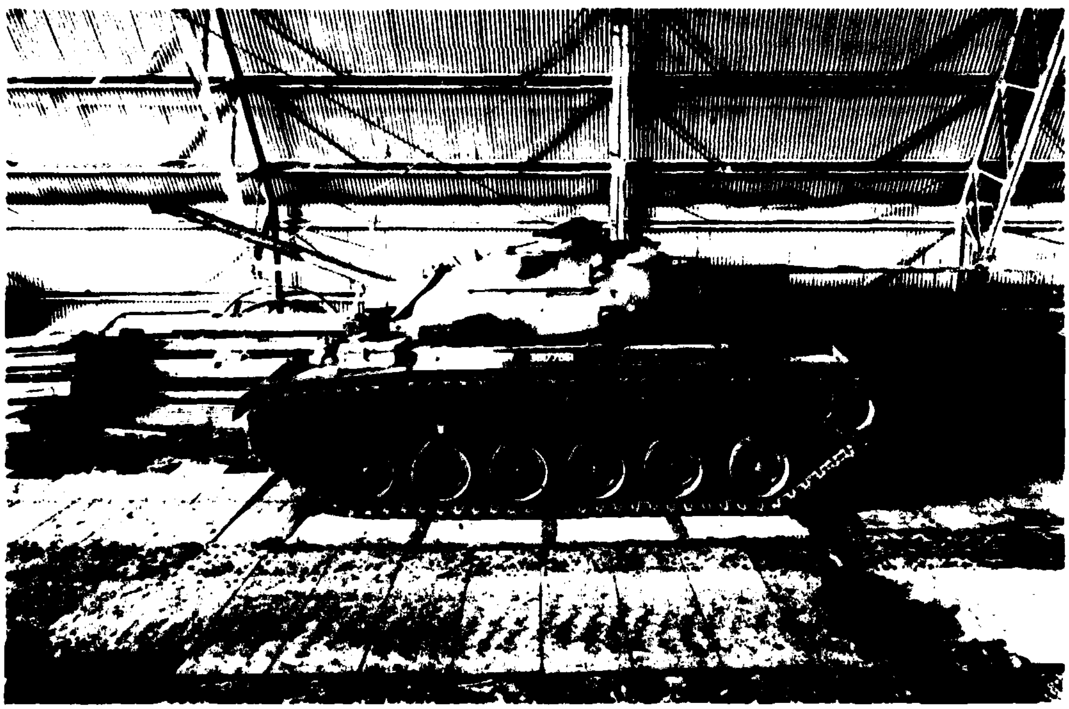


Photo 36. M8A1 tank (gross load, 106,000 lb) used
as test vehicle on M. C. Gill panels

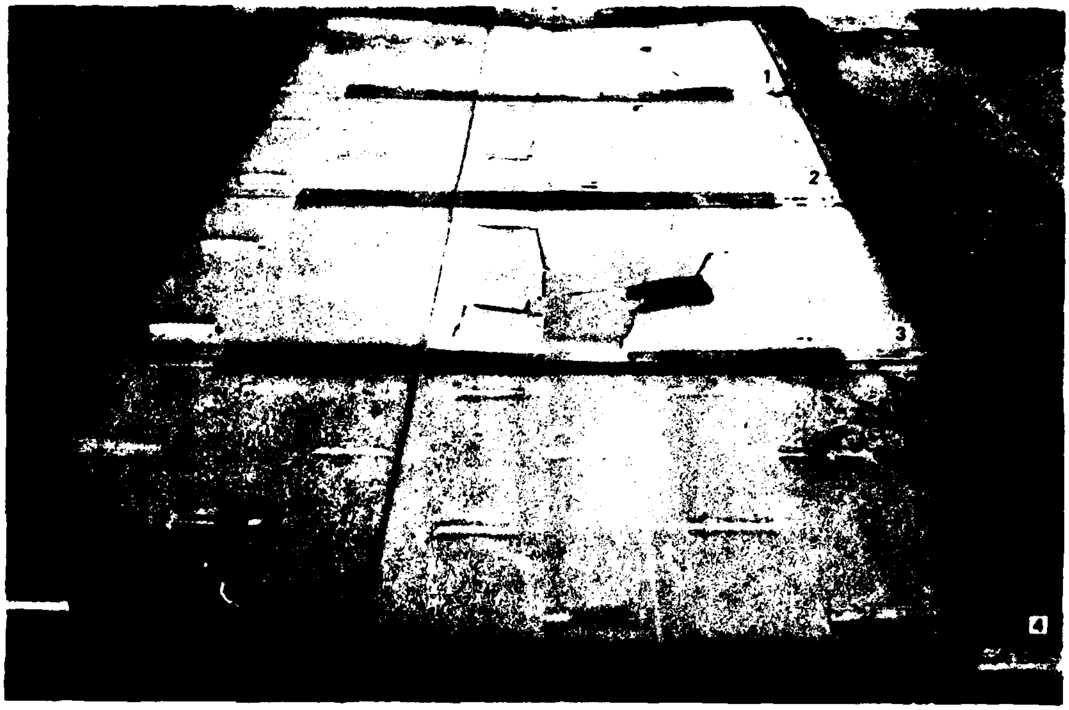


Photo 37. General view of item 2 at failure after 1920 passes (200 tank and 1720 truck passes)

Photo 38. Five-ton truck on panel 3 after 1920 passes (200 tank and 1720 truck passes)

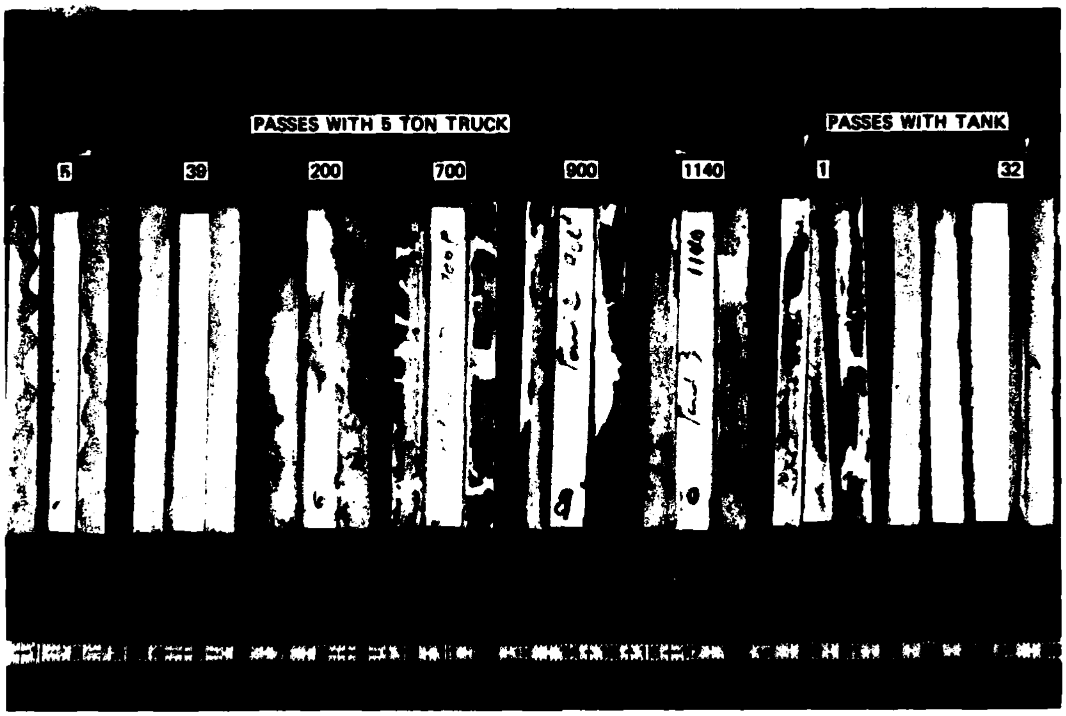


Photo 39. Cleats that failed and were torn from M. C. Gill panels; failures indicated at various phases

Photo 40. Subgrade beneath panel 2 after test at 1920 passes (200 tank and 1740 truck passes); note cleats embedded in subgrade

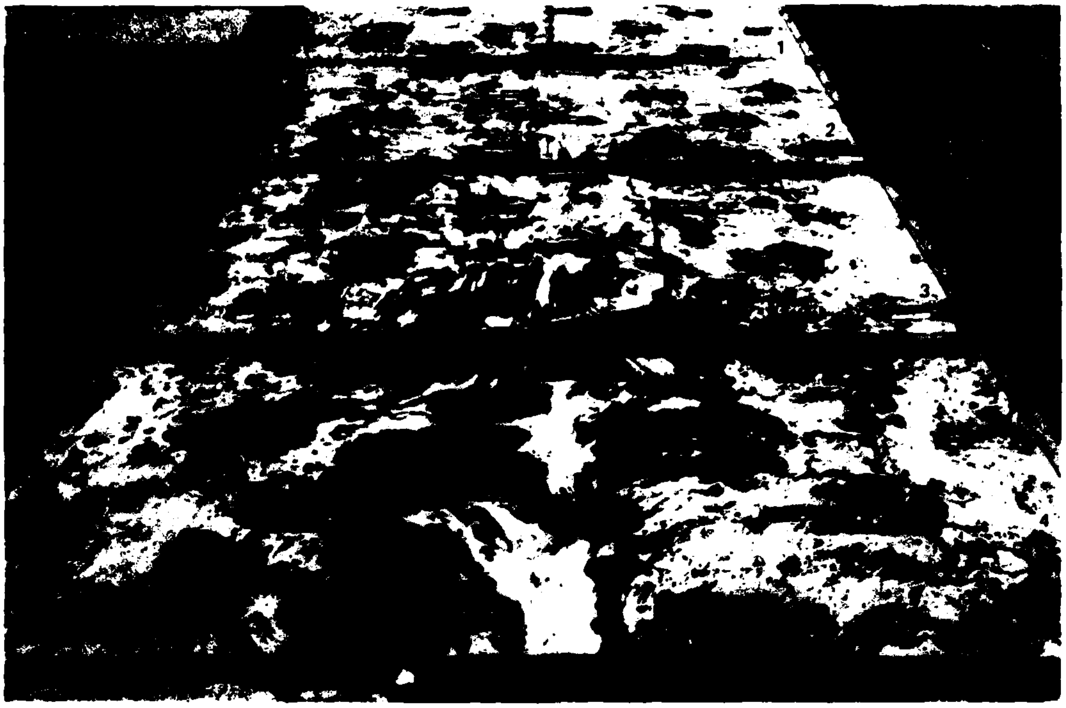


Photo 41. General view showing bottom side of M. C. Gill panels in item 2 at failure after 1920 passes (200 tank and 1720 truck passes)

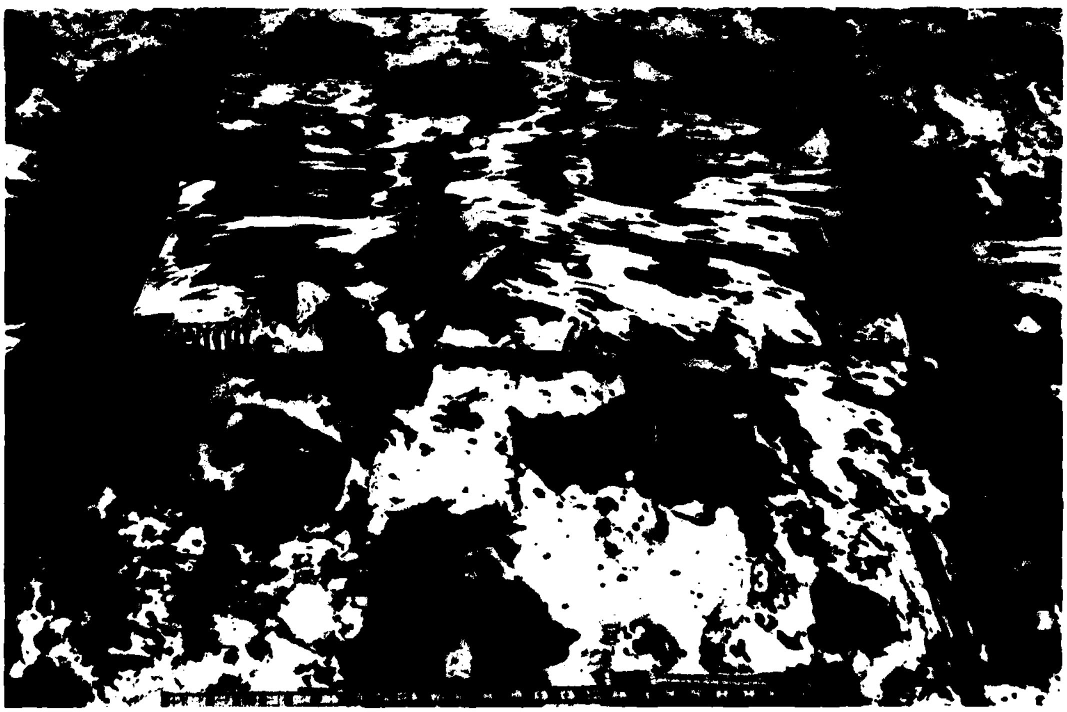


Photo 42. Close-up of bottom side of panel 3 at failure after 1920 passes (200 tank and 1720 truck passes)

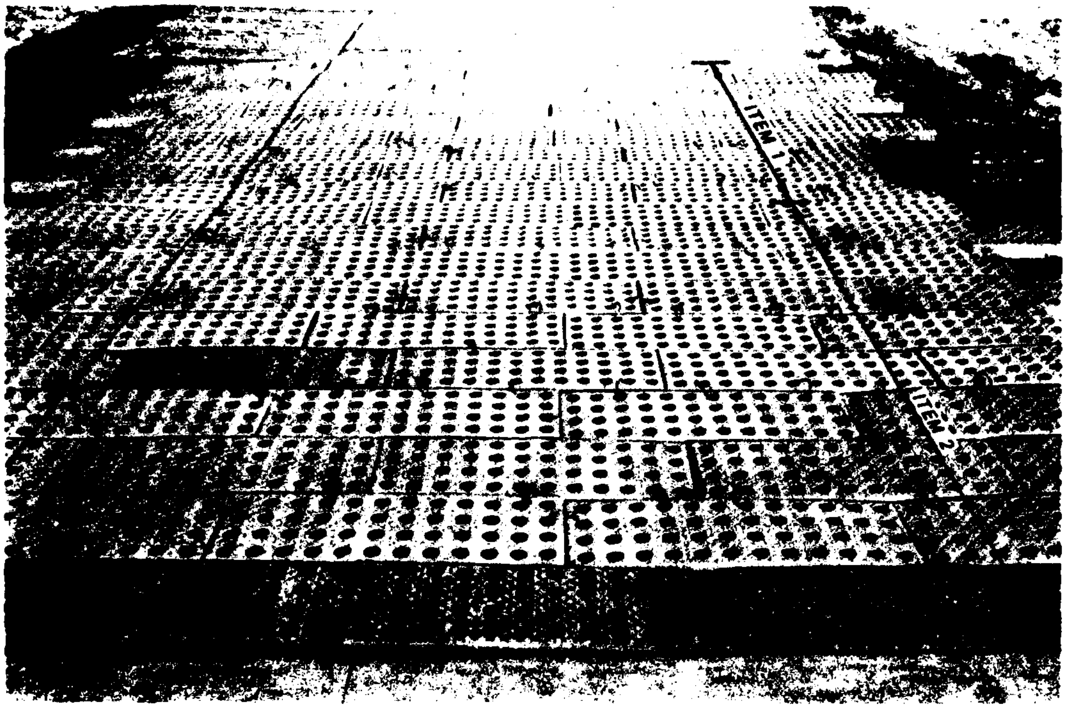


Photo 43. General view of test section covered with Sod Saver Blocks before traffic, test II

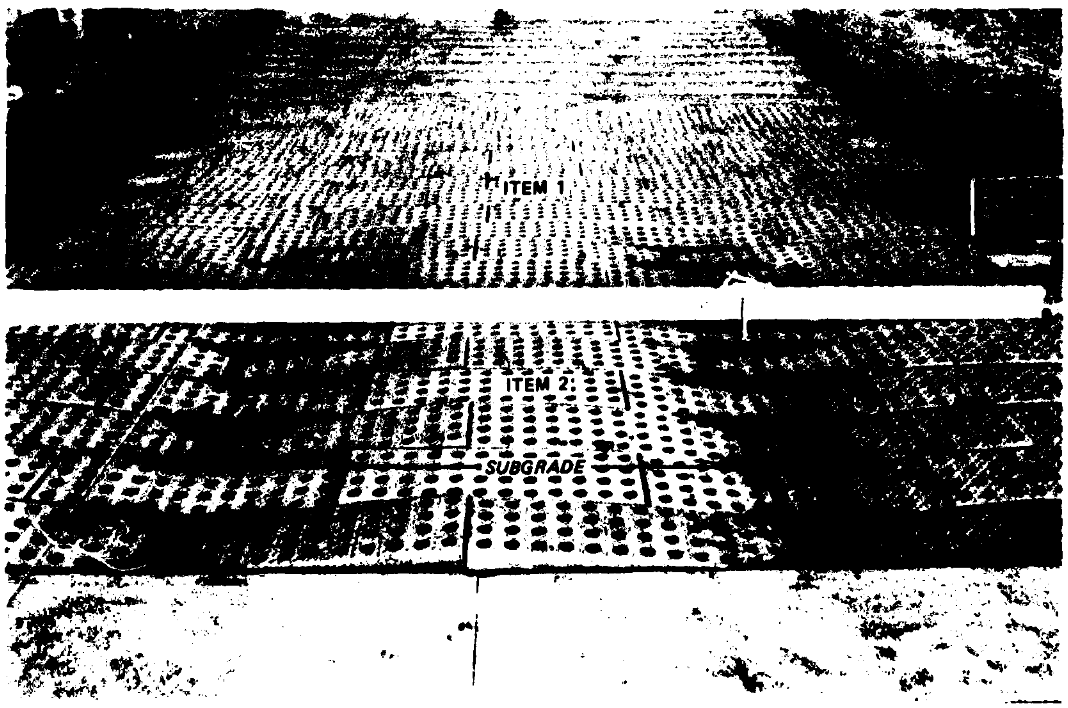


Photo 44. General view of test section after 50 passes with 5-ton truck; note permanent deformation and subgrade pumping in item 2, test II

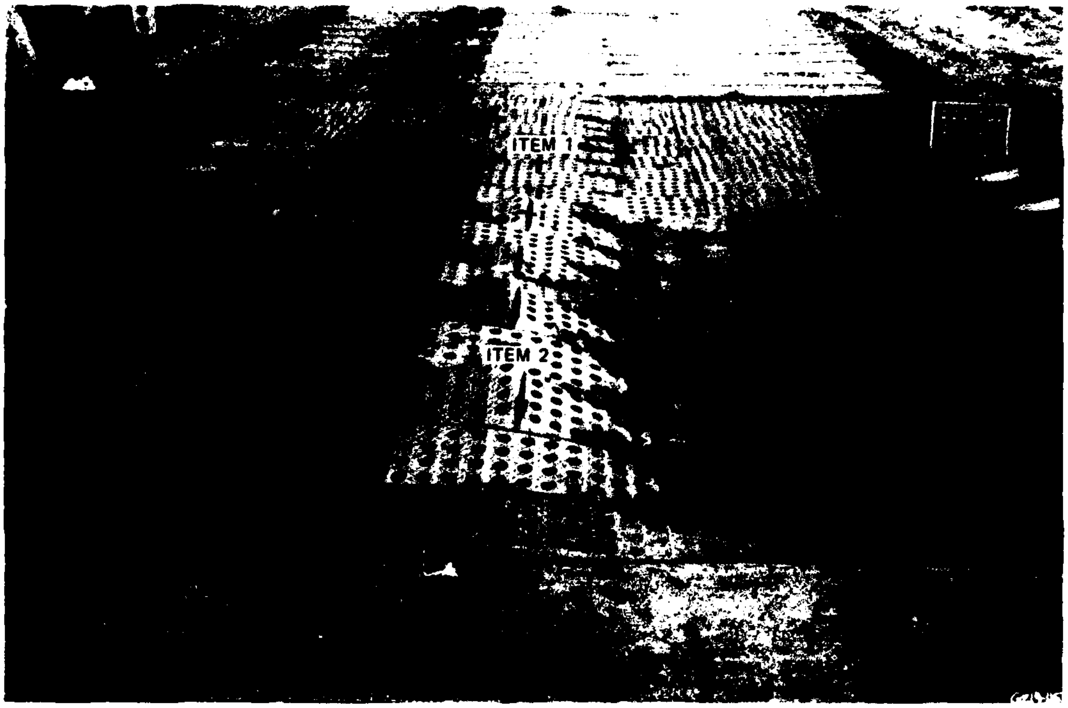


Photo 45. General view of test section showing item 2 failed after 158 passes (25 tank and 133 truck passes), test II

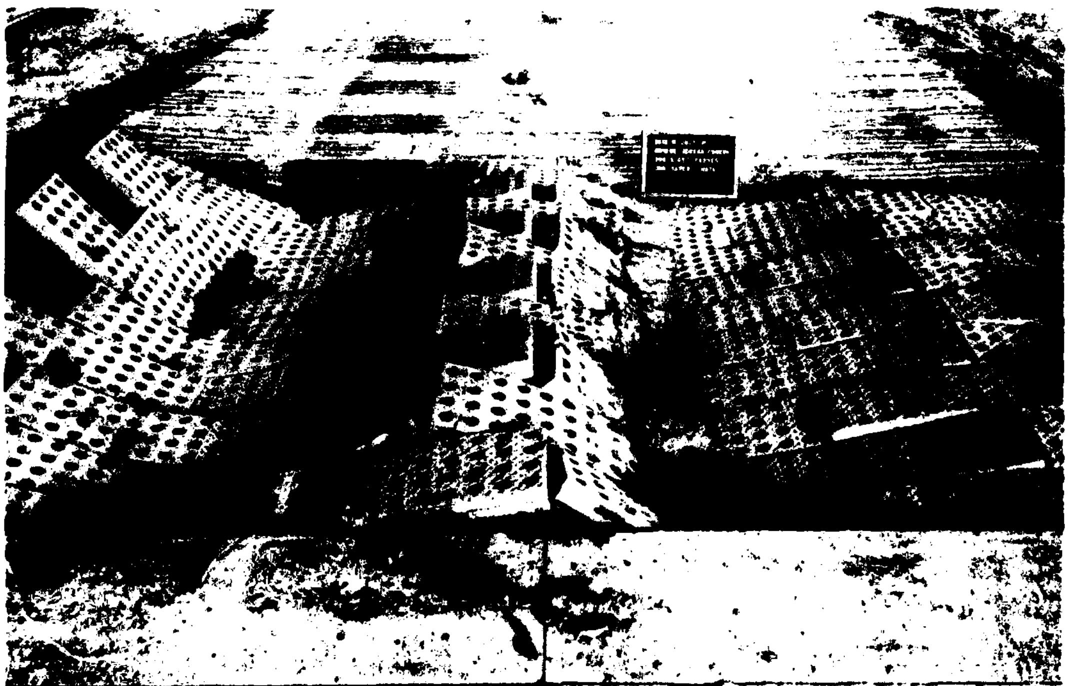


Photo 46. Item 1 (with runners) failed after 325 passes (25 tank and 300 truck passes), test II

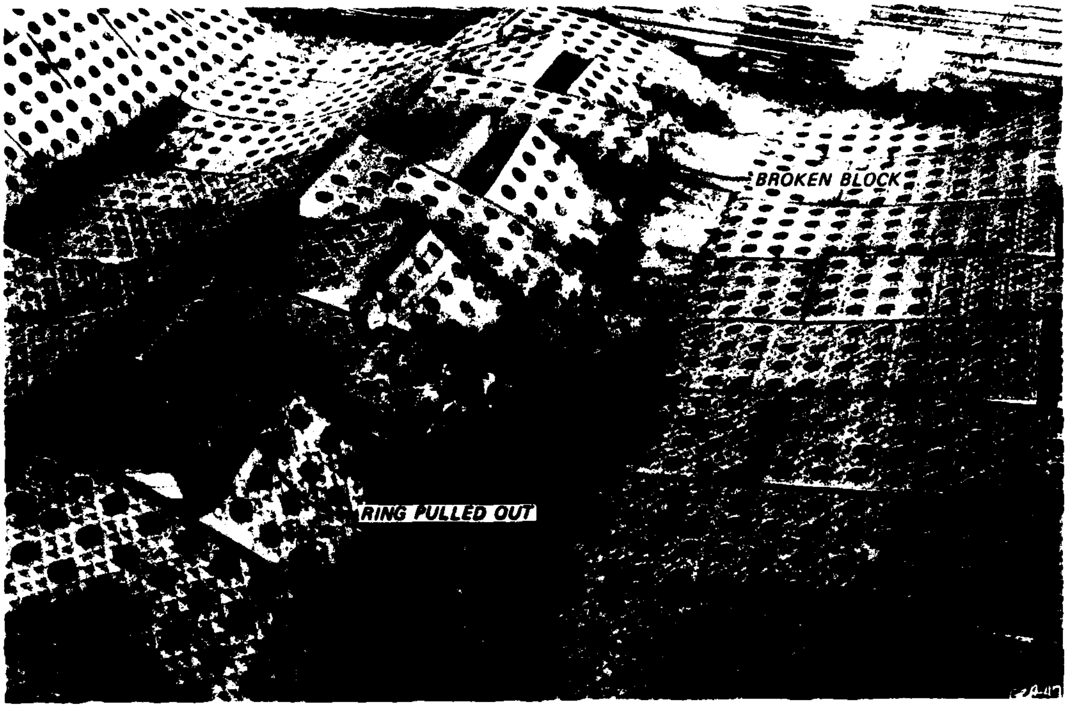


Photo 47. Close-up view of item 1 (with runners) failed after 325 passes (25 tank and 300 truck passes), test II

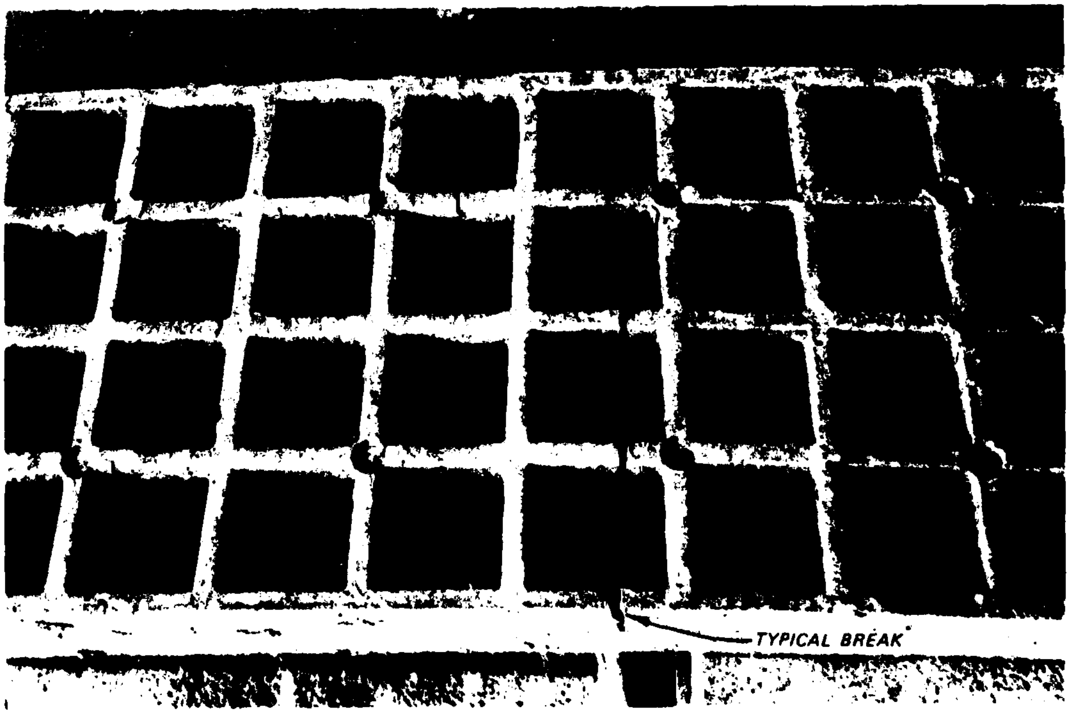


Photo 48. Close-up of a typical break in the bottom of a Sod Saver Block at failure

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Ellison, Dave A.
Evaluation of Sod Saver Blocks and M. C. Gill panels for tactical bridge access/egress applications / by Dave A. Ellison (Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, 1982.
20, [44] p. : ill. ; 27 cm. -- (Miscellaneous paper ; GL-82-17)
Cover title.
"October 1982."
Final report.
"Prepared for Office, Chief of Engineers, U.S. Army under Project No. 4A762719AT40, Task BO, Work Unit 028."

1. Materials--Testing. 2. Military bridges. 3. Trafficability. 4. Vehicles, Military. I. United States. Army. Corps of Engineers. Office of the Chief of Engineers. II. U.S. Army Engineer Waterways

Ellison, Dave A.
Evaluation of Sod Saver Blocks and M. C. Gill : ... 1982.
(Card 2)

Experiment Station. Geotechnical Laboratory. III. Title IV. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; GL-82-17.
TA7.W34m no.GL-82-17

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